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DEPARTMENT OF HORTICULTURE

EFFECT OF RETAIL PACKAGING MATERIAL AND STORAGE TEMPERATURE ON THE KEEPING QUALITY OF FRESH-CUT SOLO PAPAYA FRUITS SOLD IN THE KUMASI METROPOLIS

BY

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(BSC AGRIC-TECHNOLOGY)

APRIL, 2016

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A Thesis Submitted to the School of Research and Graduate Studies, Kwame Nkrumah University of Science and Technology, in Partial Fulfillment of the Requirement for the Award of Masters in Philosophy

(MPhil. Postharvest Physiology)

APRIL, 2016

DECLARATION

I hereby declare that, except for specific references which have been duly acknowledged, this work is the result of my research and it has not been submitted either in part or whole for any other degree elsewhere.

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DEDICATION

This work is dedicated to my parents (Mr. and Mrs. Daniel Nsoh Akitame), my beautiful wife and daughter and my siblings.

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My maiden gratitude and praise go to the omnipotent God, for his immense wisdom, direction and strength throughout my entire postgraduate education.

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ABSTRACT

This research was conducted to determine the effect of retail packaging material and storage temperature on the keeping quality of fresh-cut solo papaya fruits sold in the Kumasi Metropolis. The experiment was conducted in three parts, namely a survey and two laboratory experiments. Field survey was carried out in five major markets in the Kumasi Metropolis of the Ashanti region of Ghana. Interviews together with semi-structured questionnaires were used to collect data from 160 respondents, randomly. Fresh-cut sunrise-reddish papaya fruits in three different packaging materials collected randomly from the surveyed markets at two different times, were studied for the effect of the packaging material on the firmness, moisture content, total soluble solids, pH, as well as microbial load. Further on, papaya fruits at the breaker stage, harvested from a commercial orchard at Nobewam in the Ashanti region of Ghana, were processed and packaged in three different packaging materials and stored at 5°C for 9 days for the determination of the effect of the packaging and storage environment on their keeping quality every two days. The survey revealed that, majority (84%) of the retailers used Polyethylene films, while a few (16%) used the Clam Shell packaging. Sunrise-reddish papaya was better patronised than the Kapoho-yellow by both retailers and consumers alike who were both supplied by the wholesalers. Majority of consumers (69%) preferred buying fresh-cut Sunrisereddish papaya fruits in Polyethylene films which were displayed under shade. Laboratory experiment revealed that, the packaging materials did not significantly

($p>0.01$) influence the firmness, moisture content and ph of fresh-cut SunriseReddish papaya fruits under ambient temperature. However, the interaction between the packaging materials and method of display revealed that, fresh-cut SunriseReddish papaya fruits in all the packaging materials under Hawked condition, were

significantly ($p<0.01$) higher in firmness and and Total Tiratable acidity than shaded fruits. Contrary, the interaction effect demonstrated that fresh-cut sunrise-reddish papaya fruits under shaded condition were significantly ($p<0.01$) higher in pH than hawked fruits. Laboratory experiment revealed that, over time, fruits in Zip lock retained their Total Soluble Solids and Total Titratabla acidity better than those in Polyethylene films, which were also firmer than those in Zip locks at 5°C. Staphylococcus count of fresh-cut papaya fruits in zip lock recorded the lowest count. pH of fresh-cut papaya increased significantly ($p< 0.01$) in Zip lock than Clam shell on day 9. Regarding shelf-life, Zip lock recorded a higher significant ($p<0.01$) colour and aroma score than the rest of the packaging materials. Moreover, fresh-cut sunrise-reddish papaya fruits packaged in Zip lock were significantly ($p< 0.01$) high in *E.coli* count on day 7. Counts of *E.coli* and *Staphylococcus* were within the acceptable range. It can be concluded that, zip lock as a retail packaging material, gave a better keeping quality of moisture content, total soluble solids total titratable acidity, shelf-life than polyethylene films and clam shells under ambient and refrigerated conditions.

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1.0 INTRODUCTION

The quest for quality, convenience as well as healthy foods by consumers has resulted in minimal preparation/processing of the food prior to packaging and storage at low temperature (Rivera-Lopez *et al*, .2005). Nwachukwu *et al*. (2008) noted that consumption of sliced fruits has been on the increase since they are easily accessible, convenient and most especially cheaper than the whole fruit. Fresh-cut produce is a new agricultural industry that grows steadily and increases its popularity among other agricultural industries (Anonymous, 2005).

Papaya is commonly used as fresh in whole pieces, in fruit as well as in chunks. Papaya is also used to prepare juices, sauces and other products. Fresh fruits and vegetables are considered as an important component of human diet and there is enough proof to validate the positive correlation between fruits and vegetables consumption and good health and nutritional benefits (Abadias *et al*., 2008). Furthermore, the nutritional value which provides essential vitamins, minerals, protein dietary fiber and calcium are well documented. Kalia and Gupta (2006) reported that, regular consumption of fruits and vegetables is very important since they can prevent certain nutritional deficiencies as well reduce the risk of many diseases. This is buttressed by Keller and Tukuitonga (2007) who reported that, they prevent micronutrient deficiencies.

FAOSTAT (2008) reported the world production of papaya to be approximately 9.1 million tones. It further points out that, although an erratic growth was experienced, export of papaya had an increased trend from 2002 to 2009 globally.

Papaya contributes immensely to the economic development of Ghana through the local and international markets. The natural condition of the country places her advantageously as a major producer and exporter of papaya coupled with the favourable environmental conditions (Mashahudu, 2009). According to the Ghana Export Promotion Council (2000), Ghana contributes 3 % of the 53 million euro of the European Union papaya market.

However, the acceptability of fruits and vegetables depends immensely on how they are packaged and presented. Laminated or coextruded films and flexible packs are the basic plastic films developed for the packaging of minimally processed produce. Some of the main materials used for the elaboration of flexible packs are: High densitypolyethylene (HDPE), Polyvinylchloride (PVC), Polypropylene and Polyamides (Cortez, 2004). By having different properties, these packing materials would also show different behaviours in fresh-cut papaya fruits.

Papaya is a popular tropical fruit requiring preparation before consumption. Papaya is faced with a myriad of problems as a fresh-cut fruit. Poor post-harvesthandling of fruits and vegetables has been a serious bottleneck that deserves the needed attention. FAO (2006) reported that, papaya has suffered postharvest losses ranging from 30 to 60 % in the South-east Asia. Thus, simple technology and practices have helped to reduce losses and extend storage life. However, the major obstacle of papaya among many others as a fresh-cut fruit is their short life, leading to quick degeneration and decomposition of the produce and undesirable looks and negative palatability. The growing demand for minimally processed products has urged researchers to focus most of their effort in studying new ways of extending the shelf life.

Extensive work has been done in packaging for many decades. However, retail packaging as most often practiced by our traditional retailers has not been widely researched into. The importance of papaya as indicated above cannot be down played.

In this regard the prerequisite of remedial measure is to identify the type of retail packaging materials of fresh-cut papaya fruits and subsequently determine their effect on fresh-cut papaya stored under ambient and refrigerated conditions. The main objective of the research was therefore to determine the effect of retail packaging material and storage temperature on the keeping quality of fresh-cut solo papaya fruits sold in the Kumasi Metropolis and specifically to;

1. determine the types of retail packaging materials used for packaging fresh-cut sunrise-reddish papaya fruits.
2. determine the effect of retail packaging material on the physico-chemical properties of fresh-cut sunrise-reddish papaya fruits stored at ambient and refrigerated temperature.
3. determine the effect of retail packaging material and storage temperature on microbial load on fresh-cut sunrise-reddish papaya fruits.

2.0 LITERATURE REVIEW

2. 1 TAXONOMY, ORIGIN, DISTRIBUTION AND PRODUCTION

2.1.1 Taxonomy

Cultivated papaya, *Carica papaya* L. is a rapidly growing tree-like plant in the *Caricaceae* family. In Australia, 'Papaya' cultivars characterized by red and pink flesh are distinguished from 'Pawpaw' cultivars with yellow-flesh fruits. Nakasone and Paull (1998) reported that until recently, the *Caricaceae* was believed to consist of 31 species in three genera from tropical America and one genus from equatorial Africa.

2.1.2 Origin

Carica papaya L. originates from Central America and Southern Mexico throughout the Andes of South America (Samson, 1986). The researcher further indicated that papaya belongs to the family Caricaceae with related species *Carica stipulate*, *Carica pentogona* and *Carica pubescens*.

2.1.3 Distribution

Papaya from its native country spread to the South Indians, and the entire Caribbean. Papaya was also taken to Pacific Islands and Europe. According to Pope (1930), Introduction of papaya into Hawaiian was in the 1800s and is the only commercial production papaya state in U.S.A. Papaya seeds were transported to West Indies Philippines Africa and the Indo-pak subcontinent prior to the 17th Century (Reid, 1990).

2.2 DESCRIPTION

2.2.1 Growth

Papaya is a perennial fruit crop that grows up to about 9.14 m high. Papaya is unbranched but will branch only when injured (Chia *et al*., 1989). Earlier research by Samson (1986) pointed out that the diameter may be from 5.1-7.5 cm to cover a foot at the base. Papaya trunk is straight and cylindrical distinct leaf scars.

2.2.2 Foliage

Papaya leaves appear directly from the top stem in a spiral on horizontal petioles 3065 cm long. The blade, with distinct yellowish rib and veins, is divided into 5-9 main segments varying from 30 – 60 cm in width. Deeply lobed, palmate leaves are borne on long hollow petioles emerging from the stem apex (Chia *et al*., 1989).

2.2.3 Flowers

Papaya are dioecious or hermaphrodite plants with cultivars producing only bisexual or female flowers preferred in cultivation. Samson (1986) revealed that each flower contains many ovaries giving rise to a single flower producing multiple fruits. Male flowers which are small on long stalks are distinguished from female flowers which are pear-like are equally different from bisexual flowers which are cylindrical.

2.2.4 Fruits

Two types of fruits namely, Hawaiian and Mexican were identified by Chia *et al.* (1989). The Hawaiian papaya is pear shaped weighing about 0.5-2.0kg.The flesh is bright orange or pinkish, depending on the variety. The same authors also reported that fruit harvesting is easier since they rarely grow taller than 3 m. The Mexican papaya is distinguished from the Hawaiian papaya by much larger and weight up to 5 kg and more than 30 cm. The flesh may be orange or yellow. They are easier to grow (Chia *et al*., 1989).

2.3 CULTIVARS

High yielding, fitness for export, good texture of flesh, high sugar content, resistant to pest and diseases are some of the reasons for the improvement of cultivars. According to Musthusamy (2008) the solo variety is valued for its productivity, uniform shape and size, and excellent fruit quality. The same researcher revealed that the solo strains are predominantly self-pollinated and therefore are highly in red and uniform.

The sunrise variety is pear-shaped with a slight neck. Averagely, this variety weighs 662.0 g - 737.1 g depending on the location. Sunrise variety has smooth skin, flesh firm, reddish-orange, and sweet with high sugar content (Musthusamy, 2008). The fruits mature about 9 months after transplanting.

The vista is also a solo variety which is medium to large fruit depending on the diameter, 12.5 cm wide, up to 45 cm long. Popenoe (1974) described the vista variety as hardy and compact producing high quality fruits. It has a yellow skin with orange-yellow flesh.

Another solo variety is the Waimanalo. This variety has round fruits, short neck and an average weight of 4-1 11kg. It has a smooth skin, glossy with star shaped cavity (Maxwell *et al.,* 1984). Samson (1986) revealed that Waimanalo is firm, thick flesh, orange- yellow in flavour and high quality frits that can keep well. This variety is ideal for fresh market processing.

The sunset variety is small to medium-sized, pear-shaped fruit. It has orange-red skin and flesh. This type of variety is dwarf, very small and high yielding. According to Morton (1987) it originated at the University of Hawaii.

2.4 USES OF PAPAYA

2.4.1 Nutritional Use

Fruits and vegetables are essential parts of people's diet and are vital for health and well-being. Fruits are rich in vitamins, minerals, antioxidant and many phytonutrients. Papaya is an excellent quality fruit, high in vitamin A. 'Daddawa', Nigerian food, is produced from papaya seeds (Dakare 2004). According to OGTR (2008), reported that, papain is used in the food industries feed industries, as well as the pharmaceutical industries.

2.4.2 Medicinal Use

Numerous studies have demonstrated that fruits and vegetables contain bioactive compounds with antioxidant and antimicrobial capacity from different chemical classes such as phenolic compounds, carotenoids, vitamins (Gonzalez-Aguilar *et al*., 2003). These were shown to help prevent cardiovascular diseases (Hu, 2003), atherosclerosis, decrease the risk of some types of cancers, among other health benefits (Yahia, 2009).

Various parts of the pawpaw plant such as seed, leaf, root, stem, bark, latex and fruit possess many biologically active phytochemicals. The leaf tea has reputation as tumor destroying agent (Walter, 2008). The fresh green tea act as antiseptic and dried leaves is best as tonic blood purifier (Nwofia *et al*., 2012).

2.4.3 Industrial Use

Papaya also has several industrial uses. Biochemically, its leaves and fruits are complex, producing several proteins and alkaloids with important pharmaceutical and industrial applications (El Moussaoui *et al*., 2001). In the food biotechnology, papain is used in the production of chewing gums, for chill-proofing beer, in tenderizing meat, in the preparation of protein concentrates for animal feed, in the development of roast beef-like flavors by partial hydrolysis of proteins, for production of dehydrated pulses and beans, and in the improvement of the protein dispensability index of soya flour (Practical Action, 2006; Papaya Genome Project 2007). The authors also noticed that in the pharmaceutical/ cosmetic industries, it is a component of soap, shampoo, lotions, skin care products and tooth paste

2.5 CHEMICAL COMPOSITION OF PAPAYA

The main constituent of *Carica* papaya fruit is water relative to other fruits. According to USDA (2009) the major components of papaya dry matter are carbohydrates. Two main types of carbohydrates are in papaya fruits, namely the cell gall polysaccharides and soluble sugars. Thus during an early stage of fruit development, glucose is the main sugar. The dry matter content increases during fruit development from unripe to ripe stages (Chavasit *et al.,* 2002). Furthermore, stages of maturity affect the nutrient content of fruits like the vitamin C content of pawpaw increases with ripening (Bari *et al.,* 2006).

The edible portion of papaya contains both macro and micro nutrients. Calcium, magnesium, phosphorus and potassium constitute the macro nutrients on one hand while iron, copper zinc, manganese and selenium make up the micro nutrientson the other hand as evidenced by USDA (2009).

2.6 HARVEST AND POSTHARVEST HANDLING OF PAPAYA FRUITS

2.6.1 Harvest

Postharvest handling commences at harvest. Research available indicates that the maturity of the fruit at harvest has subsequent effect on the postharvest quality and shelf life. Harvesting of papaya is accomplished by either hand or mechanically assisted picking devices. Maturity at harvest is the most significant determinant of storage life and fruit quality. Papaya fruit should be harvested when colour of the skin changes from dark green to light green and when a yellow streak begins development. This is confirmed by Reid (2002) that papaya fruits should be harvested after colour break when some yellow shows on the fruit but before completely yellow about 9 - 12 months after transplanting.

Many preharvest and postharvest factors such as genetics, cultural practices, maturity at harvest and postharvest handling techniques affect composition and quality of fruit by the time it gets to the consumer domain. Conversely, postharvest treatments cannot improve the quality of a ripped fruit on the plant, but rather slow down the deterioration rate (Kader, 2002). This is generally true of both climacteric and nonclimacteric. The author reported that the higher the respiration rates of a fruit, the shorter the postharvest shelf life.

2.6.2 Maturity Indices of Papaya Fruit

Various definitions have been assigned to maturity from various schools of thought. Postharvest technologist views maturity as the stage of development which will permit at least the minimum acceptable quality after harvest and postharvest handling. However, horticultural maturity has been defined as the stage of development at which a plant or plant part embraces the features for consumption. Quality of the market fruit which is influenced by the stage of fruit ripening and the time of harvest, many maturity indices have been development with the motive of predicting or identifying the best time of harvest. According to Kader (2002) most commonly maturity indices are those that compromise between marketing needs and optimum consumer quality.

In fruit production, physical features such as size, abscission force, colour, texture, titratable acidity and changes in total soluble solids and physiological features such as respiration and ethylene production have been useful tools for maturity index development (Reid 2002; Thompson, 2003). However, the lack of distinctive colour changes impedes visual detection of ripening, and thus demands touching the fruit to detect softening.

2.6.3 Papaya Fruit Ripening

During ripening, the fruit goes through biochemical, physiological and structural changes; specific taste and scent are created together with increasein sweetness, pulp softening and changes in coloration making the fruit poor for consumption. The process of fruit ripening is chiefly regulated by a gaseous plant hormone called ethylene (CH). The ripening speed of fruits affects both the consumer and the farmer. The eating quality and shelf-life of fresh-cut fruit products are influenced by the stage of ripeness at cutting or harvesting (Gorny *et al*., 2000).

Temperature control in storage of fruit products is fundamentally important, because increased temperature stimulate respiration and ethylene production. According to Perkins-Veazie (1999), keeping the harvested fruits under shade, in opaque or dark boxes or using white tarpaulins to reflect heat from the filled bins has the potential of reducing the load temperature by 30 %.Unpredicted ripening during storage, transportation and distribution can result in spoilage before consumption.

2.7 POSTHARVEST LOSSES, HANDLING AND TREATMENT

Postharvest harvest loss may be defined in terms of quantitative and qualitative measurement of loss of a product at any given point in time during the postharvest chain (Buyukbay *et al*., 2011). This may however bring into inclusion the change in the edibility, wholesomeness or quality of the food that affects its consumption. Numerous findings have reported fruits and vegetables losses during and after the harvest which papaya fruits is not an exception. Muntad (2009) revealed that, both the quantitative and qualitative losses occurring at all stages in the postharvest chain from harvest through to the final consumer may be given deserving attention.

The sanitary quality of harvesting field, irrigation water, storage and processing environment of the fruits and vegetables have a direct correlation in the type and level of microorganisms present in the produce (Ray and Bhunia.2007). Rinsing fruits and vegetables with vinegar has been reported to significantly reduce microbial load (Amoah *et al*., 2009). Before, consumption the consumer or the processor must ensure that all the fruits are adequately washed and even if possible with decontaminated such as vinegar must be added to the water. Tsado *et al*. (2013) reiterated that, fruits and vegetables sellers and consumers must ensure thorough washing of all products before consumption. Furthermore, street vendors selling ready to eat sliced papaya fruits must strictly observe hygienic measures to ensure that they do not serve as source of contamination to the food (Eni *et al*., 2010).

2.8 POSTHARVEST PHYSICO-CHEMICAL CHANGES IN PAPAYA FRUITS

2.8.1 Total Soluble Solids (TSS)

Sugars, vitamin C, amino acids, and some pectin are some of the soluble compounds contained in fruits. Thus, in most ripe fruits, sugar is the main component of soluble solids. Research conducted by Crisosto *et al.* (2007), noted that a TSS level of at 10 is required for the fruit to taste sweet but this value varies by commodity. Papaya TSS has been reported to be 11.5 by Sankat and Maharaja (2001). Moreover, the amount of TSS or sugar in fruits which usually increase as they mature and ripe, serves as an important index of maturity. Total soluble solids are measured with an instrument called a refractometer.

2.8.2 Titratable Acidity (TTA) and pH pH values give a measure of the acidity or alkalinity of a product, while titratable acidity gives a measure of the amount of acid present. Assessment of pH and titratable acidity are used primarily to estimate consumption quality and hidden attributes. Kader (1999) suggested the minimum SSS and maximum TTA for

acceptable flavour quality of a range of fruits. They could be considered as indicators of fruit maturity or ripeness. Acids make an important attribution to the post-harvest quality of the fruit, as taste is mainly a balance between the sugar and acid contents.

Harker (2001) revealed that there is a close relationship between total acidity and acid taste in apples. The author further explained that TSS is a good sweetness indicator for juices and other fruits.

2.8.3 Peel and Pulp Colour

The colour of fruits probably contributes significantly to the assessment of quality by the consumer than any other single factor. Therefore, peel and pulp colour is important post-harvest selection criteria. The colour of the fruit could give an indication of the state of deterioration, disease infestation, maturity and/or contamination.The market quality and consumer accept ability are significantly influenced by the colour of the fruit. The peel colour is often the majorpost-harvest criterion used by researchers, grower sand consumers to determine whether the fruitis ripe or unripe (Medlicott *et al.*, 1992).

Colour is critical as the first visual assessment of the quality of fruit. Consumers associate the colour of the peel with specific tastes or uses and they will usually buy aparticular fruit if the colour is suited to the required purpose or desire. Lill *et al.* (1989) proposed that flesh firmness in conjunction with background colour, is a reliable indicator of the picking maturity of fruits.

2.8.4 Change in Firmness

Consumers may be intending to consume fruits because of its beneficial health consequences, but taste and texture are fundamental qualities that must be satisfied for continued consumption (Harker *et al.,* 2003). Kramer (1964) indicated that assessment of firmness is the evaluation of fruit susceptibility to physical and mechanical damage which can adversely affect the ripening quality of the fruit. Storage of papaya under normal conditions undergoes a series of important textural changes as they pass through the ripening process. Therefore, the crisp, hard and green fruit turns into yellow fruit with tender and soft internal pulp at optimum ripening stage, and becomes mushy as it advances toward senescence.

Pulp firmness is often inversely related to ripening; implying that, as ripening progresses, pulp firmness declines (Smith *et al.,* 1989). Loss of pulp firmness or softening during ripening has been associated with two or three distinct processes: The maiden is the breakdown of starch to form sugar. This is preceded by the breakdown of the cell wall or reduction in the middle lamella cohesion due to solubilization of pectin substances (Palmer, 1971; Smith *et al*., 1989). Ultimately the movement of water from the peel to the pulp during ripening due to osmosis.

2.8.5 Shelf-Life

Shelf-life describes the time period that a fruit can be expected to maintaina predetermined level of quality under specified storageconditions. Shelf life of fruit is dependent on textural firmness which is due to cell wall modification which results in structural changes in starch and non-starch polysaccharides (Yashoda *et al*., 2006). Shelf life is directly proportional to firmness.

2.9 PACKAGING / LABELING

Packaging facilitates the delivery of fresh-cut products of good quality to the consumer. Packaging protects products from physical damage and prevents physical and microbiological contamination. Packaging can on some occasions, as in the case of Map, delay spoilage of products. Cut fruits and vegetables deteriorate more rapidly than intact or packaged products. Plastic films (laminated or coextruded) and flexible packs are amongst the main plastic films developed for the packing of processed products. Coextruded films (EVA, laminated aluminum) consist of a series of microperforated sheets simultaneously produced, which are subjected to a hot fusion without using adhesives (Cortez, 2004).

2.10 FRESH-CUT FRUIT PROCESSING

2.10.1 Harvesting

The first step in ensuring fruit quality is harvesting. Therefore the best consumption quality is attained when the fruits are harvested at the optimum maturity. Pawpaws are harvested manually depending on the size and age of the tree. O'Hare (1993) stated that, the fruits must have commenced to colour prior to harvesting. PerkinsVeazie (1999) noticed that wilting, shriveling, softness and high respiration rates occur as a result of harvesting in the heat of the day which ultimately shortens shelflife. Produce must be handled in such a way as to avoid damage and contamination. Medlicott (2001) expounded that, maximum care should be taken in the field during transportation to avoid damage of the fruits. Handlers must ensure that only the best quality produce is selected for fresh-cut processing.

2.10.2 Pre-cooling

Ideally, produce should be cooled to remove field heat prior to storage or processing. Cooling extends the shelf-life of the final fresh-cut product. Thompson *et al*. (2001) revealed that delays or processing can cause in direct losses and microbial contamination, and indirect losses such as flavour and nutritional quality. The author reiterated that intact fresh produce should be separated in a small cold storage area to avoid cross contamination between it and that which has been pre-cut and washed.

2.10.3 Washing and Disinfection

It is important to wash produce as soon as possible after harvest to remove damaged tissues. Potable water is a key requirement for washing the produce (Macsuga, 2007).

Lopez-Camelo (2004) indicated that, prior to washing; overly matured, inferior size, severely damaged, deformed or rotten produce should be discarded. Research available indicate that postharvest applications and treatments prior to fresh-cut processing can greatly affect quality of fresh-cut processing, such as washing with tap water, using 1-methylclycyclopropene (Ergun, 2003), and heat (Lamikanra *et al*., 2005). Before, consumption the consumer or the processor must ensure that all the fruits are adequately washed and even if possible with decontaminated such as vinegar must be added to the water (Tsado *et al*., 2013).

2.10.4 Peeling, Trimming and Deseeding

Portela and Cantwell (2001) noted that, producing fresh-cut fruit and vegetable involves some form of mechanical injury stemming from peeling, slicing, dicing, shredding or chopping. The author noted that biochemical reactions that are associated with the wounding of the tissues are responsible for the changes in quality parameters such as texture, colour, flavour and nutritional value. In small processing plants, knives are used to trim and peel fresh produce. Large processing plants make use of abrasive peelers and automated trimmers to accelerate the process. Peeling and cutting raises the respiration rate from one-fold to seven-fold relative to the same fresh whole produce (Rivera-Lopez *et al*., 2005).

2.10.5 Cutting Operations

Produce may either be chopped, sliced, shredded, peeled, diced or sectioned. These operations are done mainly by hand in many small-scale operations. Cutting and shredding should be executed with the sharpest knives made from stainless steel (Allende *et al.*, 2006). Research has shown that using a knife reduces physical damage to cut fruits and vegetables in that less stress is observed in the cells of produce cut with a sharp knife. This is evidenced by Barry-Ryan and O' Beirne (1998) who reported that carrots slices prepared using a sharp blade had a reduced microbial load and off-odour development and were characterized by a higher microscopic cellular integrity and a longer storage life than slices prepared using a blunt blade.

2.10.6 Sorting for Defects

Lopez-Camelo (2004) explained that removal of overly matured, inferior sized, damaged and rotten produce should be removed as part of the maiden operations.

Removal of defects improves uniformity of the finished fresh-cut product and enhances shelf-life.

2.10.7 Rinsing of Pre-Cut Fruits and Vegetables

It is recommended that only water of the highest quality be used for the final rinse of pre-cut fruits and vegetables. This is supported by research conducted by Macsuga (2007) that, water for washing produce should be clean water. Many operations inject chlorine as a disinfectant along with acid in order to maintain a pH range of 4.5 - 5.5 and to assure the effectiveness of chlorine. Measurement and recording of the chlorine level and the pH of wash water is therefore a critical element of any quality assurance programme.

2.10.8 Dipping

A solution such as an acidulant/antioxidant blend which comprise a combination of ascorbic acid/citric acid for example, or in an anti-softening agent such as calcium chloride are available for dipping. Calcium lactate treatment that has potent antibacterial properties has been reported by Saftner *et al*. (2003). Research conducted by Akbas and Olmez (2007) revealed that organic acid dipping contains a lot of residual antimicrobial effect relatively to ozone and chlorine treatments on the microflora of lettuce during storage.

2.11 BIOCHEMICAL CHANGES BROUGHT ABOUT BY FRESH-CUT PROCESSING

2.11.1 Colour Changes

Browning or surface darkening is one of the main physiological effects of fresh-cut processing and leads to quality loss in fresh-cut produce. It is the result of oxidation of phenolic substrates present in the produce by PPO enzymes (McEvily *et al*., 1992). The extent of browning is dependent on the concentrations of active PPO and phenolic compounds in the produce tissue, pH, temperature and oxygen available to the tissues as well as on the presence of antioxidant compounds (Kader, 2002).

2.11.2 Flavour Quality Changes

Flavonoids are a group of phenolics and polyphenolics compounds found in different fruits and vegetables (San *et al*., 2002). Minimum soluble solids content and maximum titratable acidity where suggested to be acceptable flavour quality of some fruits (Kader, 2002).

2.11.3 Changed in Nutritional Quality

Vitamins A, B6, C, thiamine, niacin, minerals and dietary fiber all contribute to the nutritional quality of fresh fruits and vegetables. Loss of water, vitamin C and increase susceptibility to decay by pathogenic microorganisms occur as a result of mechanical injury (Kader, 2002). According to Gil *et al*. (2006), fresh-cut fruits and vegetables can appear visually spoiled before any nutrient loss occurs. In the future, plant-breeding techniques may be used to create cultivars with improved nutritional attributes that are able to withstand the effects of processing.

2.11.4 Texture Quality Changes

Research conducted by Beaulieu and Lea (2007) on fresh-cut Cantaloupe prepared from four harvest maturity revealed that, instrumental texture and hand-held firmness measures decreased significantly during storage as they observed in all maturities.

2.12. MICROORGANISMS ASSOCIATED WITH FRESH-CUT FRUITS

2.12.1 *Salmonella spp*

Harris *et al.* (2003) reported that, several outbreaks of *Salmonellosis* that were attributed to Cantaloupe and Water melon occurred from *Salmonella* which were found in the rind contaminated in the field or packaging house. Parish (1998) reported that, a multi-stated is ease outbreak due to consumption of contaminated citrus juice was caused by *Salmonella*. Unicomb *et al.* (2005) recently reported that *Salmonella* outbreak in Australia and New-Zealand tahini consumption was attributed to contaminated sesame seeds.

2.12.3 *Escherichia coli (E. coli)*

E.coli was first identified as a cause of serious acute diarrhoeal illness in humans in 1982 (Riley *et al*., 1983). According to Adams and Moss (1996), who reported that presence of *E.coli* in fresh-cut fruits is used as a sanitation index. They further explain that, this microorganism in fruits indicates how food has been exposed to the environment.

3.0 MATERIALS AND METHODS

3.1 RESEARCH DESIGN

The research was conducted in three parts; a survey and two laboratory experiments. The three approaches were chosen in order to achieve all the research objectives.

3.1.1 The Field Survey

A preliminary field survey was conducted to sample views from respondents regarding the major markets in the Kumasi metropolis where sale of papaya could be found. This led to the identification of the various markets where papaya is sold in the Kumasi Metropolis. The survey, however, targeted source, transportation, processing/preparation prior to packaging and above all the types of packaging materials which are used by our traditional papaya retailers in the Kumasi Metropolis.

3.1.2 Sampling Area

The study was carried out in the Kumasi Metropolis. Five sampling areas (markets) were selected randomly in the Metropolis. The five sample areas (markets) were; the Central market, the Asafo Market, Roman Hill, Aboabu Market and the Bantama Market in the Kumasi Metropolis.

3.1.3 Sample Size

Sample size of one hundred and sixty (160) respondents was chosen for the study. This comprised (10) papaya wholesalers, (50) papaya retailers and (100) consumers for the study.

3.1.4 Sampling Methods

Since it was not feasible to study the entire population of the respondents, a total of 160 respondents were sampled to be representative of the population. The sampling techniques employed included both probability (simple random) and non-probability (purposive). Simple random sampling was used to select the markets while purposive sampling was used to select retailers who traded in fresh-cut papaya fruits.

3.1.5 Design of Questionnaire

Three separate semi-structured questionnaires were designed for wholesalers, retailers and consumers. Prior to this, a preliminary semi-structured questionnaire was pre-tested to the respondents in the Kumasi Metropolis. Based on the pretest, modifications were made on the questionnaires prior to their administration.

3.1.6 Questionnaire Administration

Interviews using semi-structured questionnaires were administered to wholesalers, retailers and consumers in the selected markets randomly. The questionnaires were in the form of open and close ended questions administered to (10) wholesalers, fifty (50) retailers and hundred (100) consumers from the selected sampling markets within the Kumasi Metropolis. Thus, ten (10) retailers and twenty (20) consumers each in the selected markets were randomly interviewed using the semi-structured questionnaire.

3.1.7 Data Collection

The questionnaires were administered to establish the Bio data, educational back ground, and Socio-economic background of respondents. The questionnaire also sought information on the sourcing of freshly-cut papaya, preparation of papaya fruits, packaging of fruits as well as post-harvest handling practices of packaged fresh-cut papaya from the respondents. The information collected from the survey was used to establish associations with the types of packaging materials and their effect on the keeping quality of fresh-cut sunrise-reddish papaya fruits stored under ambient and refrigerated temperatures.

3.1.8 Statistical Analysis

The raw data from the field survey were transformed for computer analysis using Microsoft Excel and SPSS. The pre-coded structured questionnaire responses were edge-coded for easy entry into Microsoft Excel. The open-ended questionnaire responses were put into similar categories in order to reduce information to a more confined attributes composing variable. They were then transferred from Microsoft Excel into the SPSS to generate the summaries, categorization and classification. A detailed analysis was then carried out on the outputs for presentation. Descriptive statistics were widely used involving frequencies and percentages of the findings. Equally, results of microbial analysis were carried out using Statistix version 10 to estimate the significant differences at 1%.

3.2 LABORATORY WORK

Two laboratory experiments to determine the effect of retail packaging material and storage temperature on the keeping quality of fresh-cut solo papaya fruits were carried out at the laboratories of the Departments of Horticulture and Biological Science of the Kwame Nkrumah University of Science and Technology (KNUST), Kumasi.

3.2.1 Experiment (I)

Processed and packaged fresh-cut Sunrise-Reddish papaya fruits at the breaker stage in three different packaging materials under three methods of display, were collected at two different times randomly to the Departments of Horticulture and Biological Science for the study of the effect of the packaging materials on their physicochemical properties and microbial load respectively.

3.2.2 Experimental Design (EXP'T I)

The first laboratory experiment was set up in a 3 x 3 x 2 factorial arrangement in a Completely Randomized Design (CRD), replicated 3 times.

The first factor was packaging materials with three levels; Polyethylene film (low density), Clam shell (high density) and Zip lock (moderate density), second factor was method of display with three levels; Shaded, Unshaded and Hawked, whiles the third factor was time with two levels; Morning and Afternoon

3.2.3 Description of Treatments Table 3.1: Description of Treatments

Treatments	Description(Film type)
Clam shell	High density polyethylene
Polyethylene film	Low density polyethylene
Zip lock	Moderate density polyethylene
Hawked	Mobile
Shaded	Stationary and shaded
Unshaded	Stationary and unshaded

Schlime and Rooney. (1994).

3.2.3 Experiment II

3.2.4 Location of Experiment

The research was carried out at the Departments of Horticulture and Biological Science laboratories of the Kwame Nkrumah University of Science and Technology, Kumasi in the Ashanti region of Ghana.

Fruits were harvested from an orchard at Nobewam in the Ashanti region of Ghana and were transported for about 1 hour to the Department of Horticulture in the morning.

Kumasi has a tropical wet and dry climate with relatively constant temperature throughout the year. Kumasi has an average rainfall of around 1400 mm per year.

The city features two different rainy seasons (bimodal), a longer rainy season from March - July and a shorter season from September - November. The month of March through to November is one long wet season, with a relative precipitation in August. Similarly to the rest of West Africa, Kumasi experiences the harmattan during the low sun months. It is located on latitude 6.67 °N and longitude 1.62 °W.

3.3 EXPERIMENTAL MATERIALS

Sunrise-reddish papaya fruits at the Breaker stage of the same variety devoid of physical blemish, pest and disease attack were harvested from a commercial orchard at Nobewam in the Ashanti region of Ghana. The fruits were then transported to the Department of Horticulture where they were sorted for equal size and shape, washed with tap water to remove the field heat and allowed to dry. The fruits were subsequently peeled, deseeded and sliced into equal sizes prior to being packaged into the different retail packaging materials. Each packaged material contained eight slices. The packaged papaya fruits were then stored under refrigerated (5 °C) conditions for determination of their physico-chemical properties and microbial load.

3.4 EXPERIMENTAL DESIGN

The second laboratory experiment was set up in 3 × 9 factorial arrangement in a Completely Randomized Deign (CRD), replicated 3 times.

The first factor was packaging materials with three levels; Polyethylene film (low density) Clam shell (high density) and Zip lock (moderate density) while the second factor was days of storage with nine levels; 1,3,5,7 and 9.

3.5 PARAMETERS STUDIED

- Pulp firmness
- Moisture content
- Total soluble solids
- pH
- Total titratable acidity
- Shelf-life
- Microbial load

3.5.1 Measurement of Firmness

Three pieces from each packaged material were placed face up on a platform. The force required to penetrate the pulp tissue with the 6 mm diameter cylindrical probe penetrometer (Instron 4442 penetrometer) was measured. The value recorded for the triplicate for the various treatments represented the forces required for each pulp to yield to the tip of the probe. The values were recorded in Newton (N).

3.5.2 Moisture Content

Three pieces from each packaged material were weighed in tarred glass dishes using a basic balance (Satorious, Gottingen, Germany). The dishes were placed in an oven (WTB Binder, Tuttlingen, Germany) at 70 °C for 48 h and then weighed again. Moisture content (g) was calculated as [(initial weight of dish with samples - weight of dish with samples after drying) / initial weight of dishes with sample] x100.

3.5.3 Total Soluble Solids (TSS)

Total soluble solids in the papaya juice were determined as follows; according to the method of Dadzie and Orchards (1992). Thirty (30) grams of the pulp tissue was blended in a kitchen blender with 90 ml distilled water and filtered using a filter paper. A single drop of the filtered juice was placed in the prism of the refractometer (Atago N-McCormick fruit Tech., brix ranges from 0 – 20 % at 25 °C). The refractometer was pointed towards a light source and the percentage total soluble solids read. The result was expressed in percentages.

3.5.4 Total Titratable Acidity (TTA)

Total titratable acidity of the papaya fruit was measured as follows:

Thirty (30) grams of fresh pulp tissue was weighed into a kitchen blender and 90 ml distilled water added. This was blended for 2 minutes and filtered using a sieving net. Twenty-five (25) ml of the filtrate was transferred into a conical flask. Twenty - five

(25) ml of distilled water and 4 - 5 drops of phenolphthalein indicator were added. A 25 ml burette was filled with 0.1 M sodium hydroxide (NaOH) and adjusted to the zero mark after eliminating the bubbles. The 0.1 M NaOH was titrated with the filtrate and until the indicator just changes pink/red. The titre volume of the NaOH added was recorded. The acidity of the juice was expressed as percentage citric acid (g anhydrous citric acid/100 ml juice, (Codex Alimentarius, 1992).

3.5.5 pH Determination

Thirty grams of the pulp tissue was weighed into a kitchen blender and 90 ml of distilled water was added and then blended and the content was filtered using a filter paper (AOAC, 1990). The pH (Model 420A, Orion Research, and Beverly, MA) electrode was washed in distilled water and the electrode placed in the filtrate it was allowed for 5 minutes for reading to be stabilized. The pH value of the filtrate was then recorded.

3.5.6 Measurement of Shelf-Life

Shelf -life was assessed subjectively using a Hedonic scale (score) on colour, texture and aroma as described below. The aforementioned parameters were printed on a sheet and given out to students to score the triplicates packaging materials with fruits in terms of fair, good and excellent under refrigerated condition every two days. Shelf-life parameters were monitored consecutively for 9 days. Colour of the fruits was assessed by visual inspection, texture by hand felt and aroma by smell.

According to Bai *et al.* (2003), the sensory characteristics were evaluated using the following grading categories.

Table 3.3: Description of Shelf-life Parameters of fresh-cut papaya fruits

Parameter	Description	Scale (Score)
Colour	Golden- orange	3- Excellent

	Light golden- orange	2-Good (up to 5%)
	Brown	1-Fair (6-20% affected)
Texture	Hard	3 - Excellent
	Soft	2 – Good (up to5 % affected)
	Watery	1 – Fair (6-20% affected)
Aroma	Soft fruity	3 - Excellent
	Sharp	2 – Good (up to 5% affected)
	Fermented	1-Fair (6-20% affected)

3.5.7 Microbial Load

3.5.7.1 Methods

3.5.7.2. *Escherichia coli (E. coli)*

E.coli were isolated and enumerated by pour plate method and growth on MacConkey Agar (MA). Serial dilutions $10^{-1}$to 10^{-4} was prepared by diluting, 10 g of papaya fruit samples into 90mls of sterilized distilled water and pulcified for 15 seconds. One millitre aliquots from each of the dilution were then inoculated into Petri dishes with already prepared MA. The plates were then incubated at 35 °C for 24 hrs. After incubation, pink arrows spot were counted and recorded as *E. coli* counts using colony counter.

3.5.7.3 *Staphylococcus spp*

Staphylococcus were isolated and enumerated by pour plate method and growth on Salt Manitol Agar (SMA). Serial dilutions 10^{-1} to 10^{-4} were prepared by diluting 10 g of the sample into 90mls of sterilized distilled water and pulcified for 15 seconds. One millitre aliquots from each of the dilutions were inoculated into Petri dishes with already prepared SMA. The plates were then incubated at 35 °C for 24 hrs. After incubation, *Staphylococcus* yellow arrows spot or spread were counted and recorded as *Staphylococcus* count using the colony counter.

3.5.7.4 *Salmonella spp*

Prepared 10 ml of manufactured formula of Buffered peptone water (BPW) was in a universal bottle and serial dilution of samples added to it. It is incubated at 37 °C for 24 hrs. The 0.1 ml of the sample from the BPW is placed in a 10 ml of selenite broth in universal bottle and incubated at 44 °C for 48 hrs. Streaks from the bottle onto SS Agar and incubated at 48 hrs at 37 °C. Black colonies and cream colonies on the SS Agar indicated the presence of Salmonella.

3.6 STATISTICAL ANALYSIS

Data collected was subjected to statistical analysis using Analysis of variance (ANOVA). Statistical package used was Statistix version 10. Testing for differences between means was at 1% level ($P = 0.01$)

4.0 RESULTS

4.1 INTRODUCTION

This chapter presents results of data collected through the market survey in some selected markets in the Kumasi Metropolis. The data was gathered from wholesalers, retailers and consumers of papaya fruits through a market survey. The focus was on the demographic, sourcing, handling, processing and packaging of papaya and how these activities affected the quality of packaged freshly-cut papaya fruit.

4.2 GENDER, AGE AND RELIGIOUS AFFILIATION OF RESPONDENTS

The gender composition of consumers who participated in the survey was female (58 %) dominated. The remaining 42 percent were males. The respondents were largely (54 %) constituted of the youth within the ages of 15 to 26 years. Majority (63 %) of the consumers were not in a marital relation as compared to 47 percent who reported that they were married. Like the Region's religious composition, Christians were the dominant religious group constituting 93 percent of the consumers interviewed (see Table 4.1).

Table 4.1: Bio-Data of Consumers

CATEGORY	FREQUENCY	PERCENTAGE (%)
Gender		
Male	42	42.0
Female	58	58.0
Total	**100**	**100.0**
Age		
15-20	30	30.0
21-26	24	24.0
27-32	11	11.0
33-38	16	16.0
39 and above	19	19.0
Total	100	100.0
Marital Status		
Single	62	62.0
Married	35	35.0
Divorced	3	3.0
Total	62	62.0
Religious Affiliation		
Christianity	93	93.0
Islamic	6	6.0
Traditionalist	1	1.0
Total	100	100.0

With regard to the papaya retailers interviewed, all the respondents were females mainly between the ages of 27 to 32 years. 100 percent of the wholesalers interviewed were also females. From Table 4.2, over 80 percent of the people engaged in the papaya retail trade were married. Christianity was the dominant religion among retailers interviewed with about 94 percent of the respondents reported as being Christians. The remaining 6 percent were Muslims.

Table 4.2: Bio-Data of the Papaya Retailers

Category	Frequency	Percentage (%)
Gender		
Male	0	0.0
Female	50	100.0
Total	**50**	**100.0**
Age of Respondents		
21-26	9	18.0
27-32	23	46.0
33-38	9	18.0
39 and above	9	18.0
Total	50	100.0
Marital Status		
Single	9	18.0
Married	41	82.0
Total	50	100.0
Religious Affiliation		
Christianity	47	94.0
Islamic	3	6.0
Total	50	100.0

4.2.1 Socio-Economic Background of Respondents

From Table 4.3, over 90 percent of the consumers who participated in the survey reported of having attained some level of formal education. It was also revealed from the survey that a substantial proportion (43%) of the respondents had schooled up to the tertiary level. However, 9 percent did not attain any formal schooling.

Table 4.3: Education and Employment Background of Consumers

Category	Frequency	Percentage
Highest Level of Schooling		
Basic	19	19.0

SHS/Voc./Tech.	29	29.0
Tertiary	43	43.0
Never Schooled	9	9.0
Total	100	100.0
Employment Status		
Self-employed	48	48.0
Employee	9	9.0
Student	42	42.0
Unemployed	1	1.0
Total	**100**	**100.0**

Among the retailers surveyed, it was noticed that majority (76 %) of them had schooled only up to the basic level of education. The highest level of schooling obtained by the interviewed retailers is the secondary level. This group represented 6 percent of the retailers interviewed. However, it can be observed from Table 4.4 that a significant proportion (18 %) of the retailers had never schooled. Further analysis revealed that retailers who schooled up to the secondary level were the minority (66 %) in terms of married people. Eighty - eight (88) percent of respondents who had never schooled were married whiles 77 percent of retailers who had schooled to the basic level were married.

Table 4.4: Education Background of Retailers

Category	Frequency	Percentage
Basic	38	76.0
SHS/Voc./Tech.	3	6.0
Never Schooled	9	18.0
Total	50	100.0

The main occupation of the retailers interviewed was petty trading. From Table 4.5, 66 percent of the respondents engaged in papaya retail due to unemployment. The remaining 34 percent engaged in the business to enable them earn income to support themselves and families.

Table 4.5: Reason by Retailer for Choice of Fresh-cut PapayaBusiness

Reason	Frequency	Percentage
Unemployment	33	66.0
Desire to get money	17	34.0
Total	**50**	**100.0**

4.3 Trade and Consumption of Papaya in the Kumasi Metropolis

The field survey revealed that, a retailer was able to process and sells an average of 50 papaya fruits per day. Of the 50 retailers surveyed, 50 percent of them reported of selling less than 50 fruits daily and 44 percent sold between 50 and 100 fruits daily.

Less than 7 percent were able to sell more than 100 fruits per day (see Table 4.6). Table 4.6: Quantity of Fresh-cut Papaya Fruits Sold per Day

Quantity	Frequency	Percentage
Less than 50	25	50.0
50-100	22	44.0
101-150	1	2.0
Above 200	2	4.0
Total	50	100.0

The study further revealed that, the number of fresh-cut papaya fruits sold at a time ranged from 1 to 10 fruits per retailer (Table 4.7). Fifty-five (55) percent of the retailers reported that an average of 4 fruits were processed and packaged at a go. Table 4.7: Number of Papaya Fruits Prepared and Packaged for Sale at a Time

Quantity	Frequency	Percentage
1-3	11	22.0
4-5	26	52.0
6+	13	26.0
Total	**50**	**100.0**

Table 4.8: Time taken by Retailers to Processed and Sell Fresh-cut papaya

Time	Frequency	Percentage
1-5 mins.	9	18.0
6-15 mins.	9	18.0
16-30 mins.	21	42.0
31 mins. - 1 hr.	10	20.0
1+ hrs.	1	2.0
Total	**50**	**100.0**

4.3.1 Marketing and Sale of Papaya Fruits

The field survey revealed that, about 55 percent of consumers patronized the Sunrise – reddish papaya, 39 percent of consumers preferred the kapoho: yellow-orange variety while a few 6 percent patronized both varieties (Table 4.9).

Table 4.9: Variety of Papaya Patronized by Consumer

Variety	**Frequency**	**Percentage**
Kapoho: yellow-orange	39	39.0
Sunrise: reddish-orange	55	55.0
Both	6	6.0
Total	**100**	**100.0**

Over 72 percent of the consumers interviewed reported consuming papaya occasionally. Thirteen (13) and 15 percent eat papaya daily and weekly respectively (Table 4.10).

Table 4.10: Regularity of Purchase of Prepared Papaya Fruit by Consumer

Regularity	**Frequency**	**Percentage**
Daily	13	13.0
Weekly	15	15.0
Occasionally	72	72.0
Total	100	100.0

Table 4.11 illustrates that 60 percent of the consumers bought the fresh-cut papaya fruits from both retailers stationed under shade and hawkers/mobile retailers. However, many more consumers patronized papaya from retailers located under shade (24 %) than retailers who hawk (16 %) in the open sun.

From the interview conducted to the retailers, it was revealed that majority (95 %) of the retailers openly displayed the packaged fresh-cut papaya fruits on trays. The tray was placed on a raised platform, mostly tables or carried on the head in the case of the mobile retailers. However, some of the retailers displayed the packaged fruits on bare tables.

Table 4.11: Place Consumer Buy Fresh-cutPapaya Fruits from

Place	Frequency	Percentage
Retailers under shades	24	24.0
Papaya hawkers	16	16.0
Both	60	60.0
Total	**100**	**100.0**

Table 4.12: Factors considered by Consumers in their Choice of Retailer

Factor	Frequency	Percentage
Affordability	21	21.0
Attractiveness of packaging	48	48.0
Other reason	31	31.0
Total	100	100.0

The remaining 31 percent of the consumers mentioned other factors such as availability and proximity to retailer which serve as the basis for their choice of retailer from where to buy process papaya fruits.

4.3.2 Expenditure of Fresh-cut Papaya Retailers

The fresh-cut papaya fruit retail business was generally done on small scale. The survey revealed that, a large proportion (78 %) of the retailers expended an average amount of GH¢50 in buying papaya fruits for sale (Table 4.13). It can be observed from Table 4.13 that the highest amount spent by retailers in buying the produce was within the range of GH¢70 to GH¢100 daily.

Table 4.13: Amount Spent purchasing Papaya fruits by retailers

Amount (GH¢)	Frequency	Percentage
20-50	39	78.0
51-80	9	18.0
90+	2	4.0
Total	50	100.0

The fruit was peeled, sliced and package into varied quantities which were sold for GH¢1, GH¢1.5 And GH¢2 depending on the quantity in the package. From Table 4.14, it can be observed that about 87 percent of the consumers interviewed reported of buying fresh-cut papaya GH¢1 per package.

Table 4.14: Cost of Packaged Fresh-cut Papaya Fruit

Cost	**Frequency**	**Percentage**
GHs1	87	87.0
GHs1.5	5	5.0
GHs2	8	8.0
Total	100	100.0

4.3.3 Income of Retailers

A large proportion (70 %) of the retailers reported of profit margins between GH¢8 and GH¢15 daily. About 42 percent earned profit of GH¢10 or less. Retailers who made profits above GH¢15 daily constituted about 26 percent of the respondents interviewed (see Table 4.15).

Table 4.15: Daily Profit Margin from Papaya Sales

Amount	**Frequency**	**Percentage**
GHs 1-7	2	4.0
GHs 8-10	19	38.0
GHs 11-15	16	32.0
GHs 15+	13	26.0
Total	**50**	**100.0**

The research also attempted assessing the amount of losses made by retailers in their businesses daily. It was observed that about 84 percent of the retailers experienced daily losses to the sum of GH¢10 or less. A significant number constituting 12 percent of the retailers experienced financial losses between GH¢16 and GH¢20 daily (see Table 4.16). The remaining fruits that were not sold were doled to friends, family or animals. Only 1 out of the 50 retailers stored her unsold processed fruit in a fruit and sold them the next day.

Table 4.16: Average Amount of Daily Losses

Amount	**Frequency**	**Percentage**
GHs 1-10	42	84.0

GHs 11-15	2	4.0
GHs 16-20	6	12.0
Total	**50**	**100.0**

4.4 Sourcing and Handling of Papaya

From the survey, it was realized that about 90 percent of the retailers acquired papaya for sale from wholesalers who brought the produce directly from farmers.

Less than 15 percent of the retailers got the papaya fruits directly from the farmer.

Table 4.17: Source of Papaya and Variety Patronized

Source of Papaya	**Varieties of Papaya Acquired for Sale**			**Total Fruit**
	Kapoho: yellow-orange	Sunrise: reddish-orange	Both	
Farmers only	0	2	3	**5**
Wholesalers only	1	29	13	**43**
Farmers and Wholesalers	0	1	1	**2**
Total	**1**	**32**	**17**	**50**

From Table 4.18, majority (74 %) of the retailers reported that they purchased and sold both breaker and half-riped papaya fruits. However, 14 and 12 percent of the retailers traded in only breaker and half-riped fruits respectively.

Table 4.18: Ripening Stage of Papaya Acquired for Sale by Papaya Retailers

Stage	**Frequency**	**Percentage**
Breaker	7	14.0
Half ripe	6	12.0
Both	37	74.0
Total	**50**	**100.0**

4.5 Handling of Fresh-cutPapaya Fruits

From Table 4.19, 94 percent of the retailers travel between 1 and 5 km to buy their papaya. Retailers mainly traveled to major market centers such as the Bantama market within the Ashanti region to buy the fruits from the wholesalers. Wholesalers traveled to much far distances to buy the fruits. Analysis of the survey results indicated an average of 30 kilometers travel covered by wholesalers to purchase papaya from the farm gate.

Table 4.19: Distance between Source and Point of Sale

Distance (km)	**Retailers**		**Wholesalers**	
	Frequency	**Percentage**	**Frequency**	**Percentage**
1-5	50	100.0	0	0
6-10	0	0	0	0
11-50	0	0	8	80.0
Over 50	0	0	2	20.0
Total	**50**	**100.0**	**10**	**100.0**

The average time taken to convey the fruits from the farm gate to the market was 3 hours. About 80 percent of the wholesalers reported using about 3 hours whiles the remaining 20 percent used more time to transport the fruits to the market center. About 44 and 52 percent of the retailers used less than 1 hour and between 1 to 2 hours respectively. The remaining 4 percent however reported using over 2 hours to transport the fruits to the final sale point (Table 4.20).

Table 4.20: Time taken to Transport Papaya from Source to Point of Sale

Time (hours)	**Retailers**		**Wholesalers**	
	Frequency	Percentage	Frequency	Percentage
>1	22	44.0	0	0
1-2	26	52.0	0	0
2-3	2	4.0	8	80.0
<3	0		2	20.0
Total	**50**	**100**	**10**	**100**

Majorities (98%) of the retailers usually purchase the papaya fruit in the morning while the remaining 2 percent do so in the evening (Figure 4.1).

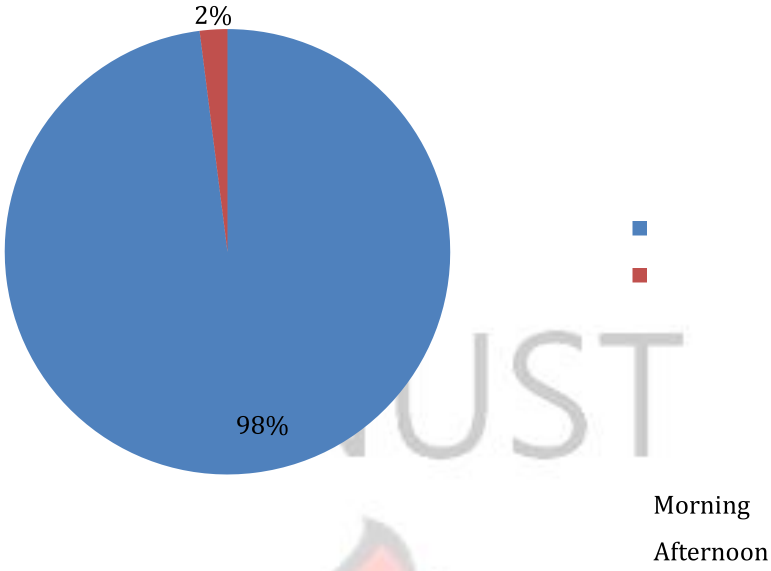

Figure 4.1: Time of Day Papaya Fruits is Purchased and Transported

Sixty-four (64) percent of retailers alluded to using taxi cabs to cart the papaya fruit while 4 percent used open trucks. The remaining 34 percent used such other means such as motor king, hand-push trucks, and head porters (Table 4.21). However, out of the 10 wholesalers interviewed, they all reported using cargo trucks to convey the fruits from the farm gate to the market.

Table 4.21: Means of Transporting Papaya Fruits by Retailers

Means of Transport	**Frequency**	**Percentage**
Open truck	2	4.0
Taxi	32	64.0
Other means	16	32.0
Total	**50**	**100.0**

Table 4.22: Average Quantity of Fruits Damaged/bruised on Arrival

Number	**Wholesalers**		**Retailers**	
	Frequency	Percentage	Frequency	Percentage
1-5	0	0.0	39	90.7
6-10	0	0.0	3	7.0
11-20	0	0.0	1	2.3

21-50	0	0.0	0	0.0
50 – 100	1	10.0	0	0.0
Above 100	9	90.0	0	0.0
Total	**10**	**100.0**	**43**	**100**

4.5 Processing and Packaging of Papaya Fruits by Retailers

From the responses of the consumers, about 53 percent confirmed that retailers use water in washing the fruits whereas the remaining 47 percent had no idea about the material or method used in cleaning the fruits before cutting (Table 4.23).

Table 4.23: Material Retailers Used in Cleaning Papaya Fruits

Method	**Consumers**		**Retailers**	
	Frequency	Percentage	Frequency	Percentage
Wash with water only	52	52.5	28	56.0
Wash with water and sponge	0	0.0	16	32.0
Wash with water and salt	0	0.0	6	12.0
Don't know	47	47.5	0	0.0
Total	99	100.0	50	100

From Table 4.24, 100 percent of retailers cleaned their cutting tools (knife) used in peeling and cutting the papaya fruits. In terms of sterilization of their cutting tools, the survey revealed that 100 percent of the retailers did not sterilize their cutting tools. Inquiring from the consumers, 95 percent of them believed that the cutting equipment used by retailers is cleaned before use while 2 percent were of the opinion that the equipment is not cleaned. The remaining 3 percent however had no idea as to whether or not the cutting equipment is cleaned before use (see Table 2.24).

Table 4.24: Are Cutting Equipment Cleaned before Use?

Response	**Consumers**		**Retailers**	
	Frequency	Percentage	Frequency	Percentage
Yes	95	95.0	50	100.0
No	2	2.0	0	0.0
Don't know	3	3.0	0	0.0
Total	100	100.0	50	100.0

From the survey, the common packaging material used by the retailers is the clear polyethylene film (84 %) commonly referred to as polythene bag. Some few (16 %) retailers use other packaging material such as clam shell plastic commonly referred to as "takeaway bowls" (see Figure 4.2).

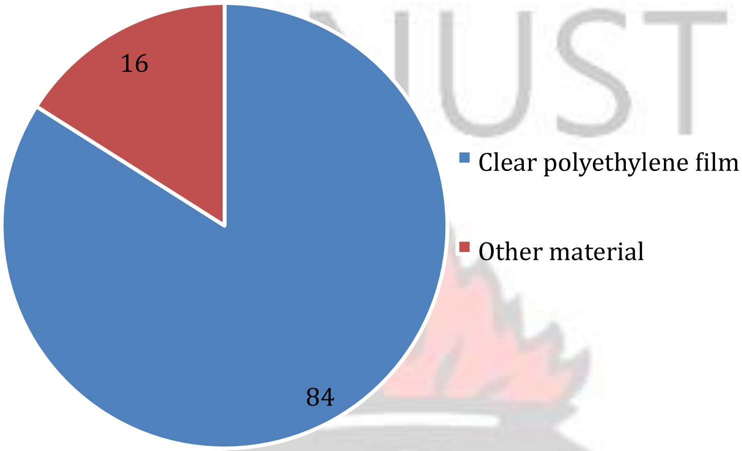

Figure 4.2: Materials Used by Retailers in Packaging Fresh-cut Papaya Fruits From Table 4.25, over 69 percent of the consumers bought their fresh-cut papaya fruits in a clear polyethylene film. Consumers who patronized the clam shell plastic formed the minority (11%) while 20 percent of them patronized both packaging materials.

Table 4.25: Consumers' Preferred Choice of Packaging Material of Fresh-cut papaya fruits

Material	Frequency	Percentage
Clear polyethylene film	69	69.0
Clam shell plastic	11	11.0
Both	20	20.0
Total	**100**	**100.0**

Over 59 percent of the retailers reported that the main determinant in thechoice of packaging material used was affordability (Figure 4.3). Furthermore, the attractiveness (32%) and the kind of material preferred by most consumers (8%) (see

Figure 4.3) also informed retailer' choice of packaging material for fresh-cut papaya.

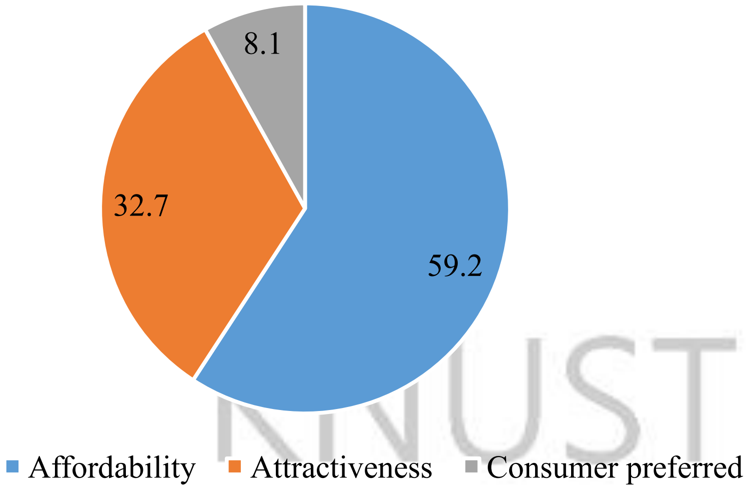

Figure 4.3: Factors that Influence Retailers' Choice of Packaging Materials

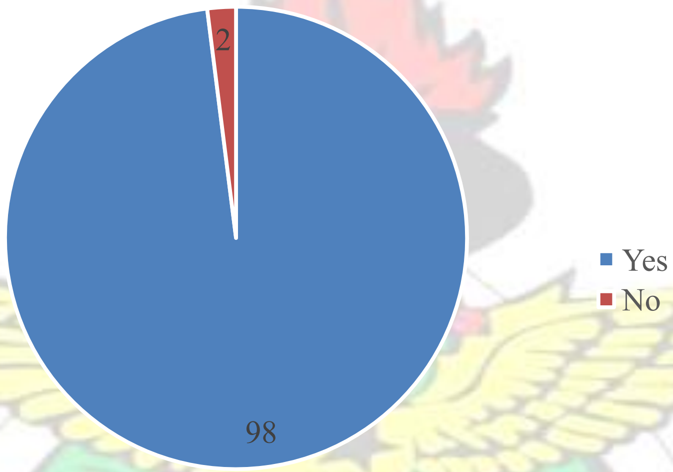

Figure 4.4: Are Retailers Willing to Adopt Effective Packaging Material?

4.5.1 Challenges in the Fresh-cutPapaya Packaging and Retail Business The study revealed that 26 percent of the retailers did not have refrigerated storage facilities for their freshly-cut papaya fruits for the unsold fruits. (See Table 4.26). Forty-four (44) percent more reported that there were no ready markets for their fruits. The survey also revealed that, transportation and inadequate capital confronting retailers recorded 14 % and 16% (Table 4.26) respectively.

Table 4.26: Problems Faced by Retailers in the Fresh-cut Papaya Business

Problem	Frequency	Percentage
Transportation	7	14
Storage facility (Refrigerator)	13	26
Inadequate capital	8	16
Lack of ready market	22	44
Total	**50**	**100.0**

4.6 Effect of Packaging on Papaya Quality and Sale

From the survey, time saving and convenienceto consumer accounted for about 80 percent of patronage of the packaged fruits (Table 4.27). Twenty (20) percent of consumers however patronized the packaged fruit due to the attractive nature of the packaging (see Table 4.27).

Table 4.27: Major Reason by Consumer for Patronage of Fresh-cutPapaya Fruits

Reason	Frequency	Percentage
Time saving	49	49.0
Convenience	31	31.0
Attractiveness	20	20.0
Total	**100**	**100.0**

The packaged fresh-cut papaya fruits were hawked or sold in unshaded structures by over 80 percent of the retailers. Less than 20 percent of the retailers were however found to operate under a shade (see Table 4.28).

Table 4.28: Location of Sale Point

Location	Frequency	Percentage
Under shade	9	18.0
Hark in the sun	10	20.0
Unshaded	31	62.0
Total	**50**	**100.0**

About 37 and 22 percent opined that the texture and taste were affected by the packaging respectively. Also, 24 percent believed that the nutritional value of the fruit is affected by packaging. However, 9 out of the 100 consumers were of the view that the packaging had no effect on the papaya fruit (see Table 4.29).

Table 4.29: Consumer Perception of Freshly-Cut Papaya as Affected by Packaging Material

Aspect Affected	**Frequency**	**Percent**
Texture	37	37.0
Taste	22	22.0
Nutritional quality	24	24.0
Other effects	8	8.0
No effect	9	9.0
Total	**100**	**100.0**

Among the 50 retailers interviewed, 34 percent of them alluded to ever receiving complaints from consumers about the quality of the packaged fruits. Poor texture quality was a common complaint received by retailers. Inquiring from the consumers, 14 of the 100 interviewed reported of ever complaining about the poor quality of package fruit to the trader (see Figure 4.5). Twenty-eight (28) and 36 percent of these consumers complained of overly soft texture and poor taste respectively whiles the remaining 36 percent experienced other effects including diarrhoea and stomach pains from consuming packaged papaya fruits (see Table 4.30).

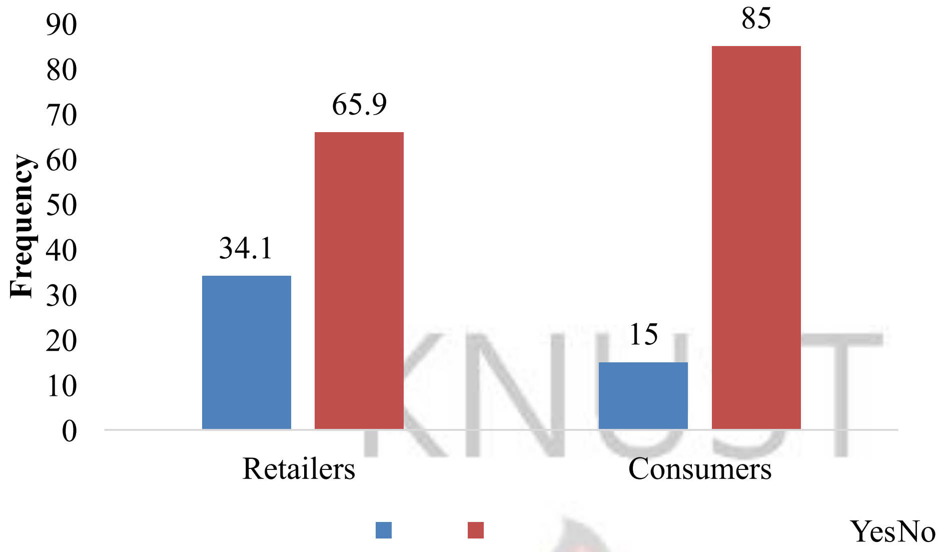

Figure 4.5: Complaints made by or received from Consumers about Quality of Packaged Fruit

Table 4.30: Consumer Complaints after Consumption of Package Papaya Fruits

Cause of Complaints	**Consumers**		**Retailers**	
	Frequency	**Percent**	**Frequency**	**Percentage**
Stomach pain/diarrhoea	5	35.7	0	0
Poor taste	5	35.7	1	5.9
Too soft	4	28.6	16	94.1
Total	14	100.0	17	100.0

With reference to the characteristics outlined in Table 4.30, it was found that 80 of the 100 consumers were of the opinion that packaging had positive effect on one or more aspects of processed papaya.

Table 4.31: Consumer Opinion on the Impact of Packaging of Fresh-cut Papaya

Characteristic	Impact of packaging			
	Positive		Negative	
	Frequency	Percentage	Frequency	Percentage
Convenience	28	28.0	0	0.0
Affordability	25	25.0	0	0.0
Attractiveness	17	17.0	6	6.0
Taste and texture	12	12.0	35	35.0
Hygiene	18	18.0	59	59.0
Total	100	100.0	100	100.0

4 out of the 100 consumers also believed that the texture and taste of the fruits was adversely affected (see Table 4.30).

4.7 RESULTS OF LABORATORY ANALYSIS (EXPERIMENT I)

4.7.1 Firmness (N)

Table 4.32: Effect of packaging material, time and method of display on the firmness of fresh-cut sunrise-reddish papaya fruits

Packaging		**Method of Display**			**Average**
Material	Time	Hawked	Shaded	Unshaded	
Clam Shell	0hrM	3.33abc	4.80a	3.90abc	4.01a
	6hr A	3.43abc	4.80a	4.37ab	4.20a
	Average	4.80a	3.38bc	4.13ab	4.11a
Polyethylene	0hr M	3.40abc	4.80a	3.93abc	4.04a
	6hrA	1.93c	4.67a	4.00abc	3.53a
	Average	4.73a	2.67c	3.97ab	3.79a
Zip Lock	0hrM	2.83abc	4.43ab	3.73abc	3.66a
	6hrA	2.37bc	5.00a	4.47abc	3.53a
	Average	4.72a	2.60c	4.10ab	3.81a
(L.s.d 1%)	Packaging material (l.s.d) = 2.92				CV = 0.66
	Method of Display (l.s.d) = 2.92				CV= 0.66
	Packaging Material* Method of Display (l.s.d) = 2.92				CV= 1.15

l.s.d = Least significant difference, M = Morning, A = Afternoon, CV = Co-efficient of variation Means with the same letters within a column are not significantly different at 1% using L.S.D.

From Table 4.32, the packaging materials did not significantly (p>0.01) influence the firmness of fresh-cut papaya fruits between the hours that the fresh-cut fruits were collected. However, fresh-cut sunrise-reddish papaya fruits in Clam shell recorded a higher firmness (4.11N), followed by Zip lock (3.81N), with polyethylene (3.71 N) recording the least firmness.

In terms of method of display, significant differences were not recorded amongst the treatments (p>0.01). However, fresh-cut sunrise-reddish papaya fruits in Clam shell recorded the highest firmness value with respect to the methods of display under consideration.

The interaction between packaging material and method of display exhibited significance (p>0.01) between the hours (0 - 6) that the fruits were collected. Thus, between the hours (0 - 6), fresh-cut sunrise-reddish papaya fruits in all the three different packaging materials were significantly (p<0.01) higher in firmness when they were displayed under hawked environments compared to shaded fruits that recorded a lower firmness value (Table 4.32).

4.7.2 Moisture Content (%)

Table 4.33: Effect of packaging material and method of display on the moisture content of fresh-cut sunrise-reddish papaya fruits

Packaging Material	Time	Method of Display: Hawked	Shaded	Unshaded	Average (%)
Clam Shell	0hrM	78.87a	83.51a	84.90a	82.42a
	6hr A	84.52a	88.69a	86.83a	86.68a
	Average	86.10a	81.70a	85.87a	84.56a
Polyethylene Film	0hr M	85.97a	87.06a	86.48a	86.51a
	6hrA	84.52a	87.50a	86.17a	86.06a
	Average	87.28a	85.25a	86.32a	86.27a
Zip Lock	0hrM	85.80a	87.81a	85.88a	86.50a
	6hrA	75.65a	86.76a	85.69a	82.70a
	Average	87.28a	80.73a	85.79a	84.60a
(L.s.d 1%)	Packaging material (l.s.d) = 2.92 CV = 5.43 Method of Display (l.s.d) = 2.92 CV= 5.43 Packaging Material* Method of Display (l.s.d) = 2.92 CV= 9.41				

l.s.d = Least significant difference, M = Morning, A = Afternoon, CV = Co-efficient of variation Means with the same letters within a column are not significantly different at 1% using L.S.D.

Generally, the moisture content of fresh-cut sunrise-reddish papaya fruits were not significantly (p>0.01) affected by the treatments irrespective of the time the fruits were collected (Table 4.33). However, fresh-cut fruits that were packaged in polyethylene film had the best moisture content (86.27 %) value with clam shell fruits recording the lowest moisture content (84.56 %).

The results also revealed that, the moisture content of fresh-cut sunrise-reddish papaya fruits were not influenced by the methods of display ($p>0.01$). Similar moisture content values in the fresh-cut fruits were recorded by Polyethylene film and Zip lock as well when they were displayed under Hawked conditions.

The effect of packaging materials and method of display on the moisture content of fresh-cut papaya fruits did not record significant ($p>0.01$) difference.. Zip lock fruits, however, exhibited a specific trend as it recorded the best moisture content under all the methods of display irrespective of the time the fruits were collected.

4.7.3 TOTAL SOLUBLE SOLIDS (°BRIX)

Table 4.34: Effect of packaging material and method of display on the Total Soluble Solids (TSS) of fresh-cut sunrise-reddish papaya fruits

Packaging Material	**Time**	Method of Display: Hawked	Shaded	Unshaded	**Average**
Clam Shell	0hrM	5.30ab	3.90b	4.47ab	4.56a
	6hr A	5.57a	4.30ab	4.73ab	4.78a
	Average	3.97e	5.43a	4.60cd	4.67a
Polyethylene Film	0hr M	5.30ab	4.30ab	4.77ab	4.79a
	6hrA	5.47ab	4.30ab	4.80ab	4.86a
	Average	4.30de	5.38a	4.78bc	4.82a
Zip lock	0hrM	5.17ab	3.90b	4.53ab	4.58a
	6hrA	5.13ab	4.30ab	4.43ab	4.62a
	Average	4.17de	5.15ab	4.48cd	4.60a
(L.s.d 1%)	Packaging Material, (l.s.d) = 2.92 CV = 0.27 Method of Display, (l.s.d) = 2.92 CV= 0.27 Packaging material* Method of Display, (l.s.d) = 2.92 CV= 0.47				

l.s.d = Least significant difference, M = Morning, A = Afternoon, CV = Co-efficient of variation, Means with the same letters within a column are not significantly different at 1% using L.S.D.

From Table 4.34, the average TSS of fresh-cut sunrise-reddish papaya fruits were not significantly (p>0.01) influenced by the different packaging materials. The best and worse TSS values were recorded by polyethylene and zip lock respectively.

Method of display did not also significantly (p>0.01) affect the TSS of fresh-cut sunrise-reddish papaya fruits. Fresh-cut sunrise-reddish papaya fruits in Polyethylene film recorded the highest TSS value (4.30°Brix) compared to fruits packaged in Clam shell that recorded the lowest value (3.97°Brix). However, this was not the case under Shaded condition, as fresh-cut sunrise-reddish papaya fruits in Clam shell recorded the best TSS value with Zip lock fruits recording the worst TSS value.

The results also revealed that, the interaction between packaging material and method of display significantly (p<0.01) influenced the TSS of fresh-cut sunrisereddish papaya fruit. Fresh-cut papaya fruits packaged in all the three different packaging materials under Shaded condition, were significantly (p<0.01) higher in TSS than their counter parts under Unshaded condition had the lowest TSS value.

4.7.4 pH

Table 4.35: Effect of packaging material and method of display on the pH of freshlycut papaya fruit

Packaging Material	Time	Method of Display: Hawked	Shaded	Unshaded	Average
Clam Shell	0hrM	4.47ab	4.17ab	4.23ab	4.29a
	6hr A	4.43ab	4.07ab	4.27ab	4.26a
	Average	4.12c	4.45ab	4.25abc	4.27a
Polyethylene	0hr M	4.53a	4.10ab	4.40ab	4.34a
	6hrA	4.43ab	4.07ab	4.23ab	4.24a
	Average	4.08c	4.48a	4.32abc	4.29a
Zip Lock	0hrM	4.47ab	4.03ab	4.13ab	4.21a
	6hrA	4.33ab	4.17ab	4.27ab	4.26a

	Average	4.10c	4.40ab	4.20bc	4.23a
(l.s.d 1%)	Packaging material, (l.s.d) = 2.92 CV = 0.16 Method of display,(l.s.d) = 2.92 CV= 0.16 Packaging material* Method of Display, (l.s.d) = 2.92 CV= 0.28				

l.s.d = Least significant difference, M = Morning, A = Afternoon, CV = Co-efficient of variation Means with the same letters within a column are not significantly different at 1% using L.S.D.

From Table 4.35, the pH of fresh-cut papaya fruits was not significantly ($p>0.01$) influenced by the treatments irrespective of the time. Fresh-cut papaya fruits in polyethylene films which recorded the highest pH was 0.02 and 0.06 times higher in pH than zip lock and clam shell respectively.

Although method of display was not statistically significant ($p<0.01$), fruits that were displayed under shaded condition had higher pH values whiles hawked fruits recorded lower pH (see Table 4.35) values.

The interaction between packaging material and method of display revealed that, fresh-cut sunrise-reddish fruits in all packaging materials under shaded condition were significantly ($p<0.01$) better in pH than hawked conditions.

4.7.5 Total Titratable Acidity (TTA)

Table 4.36: Effect of packaging material and method of display on the total titratable acidity of freshly-cut papaya fruits

Packaging Material		**Method of Display**			**Average**
	TIME	Hawked	Shaded	Unshaded	
Clam shell	0hrM	0.63bc	0.75abc	0.71abc	0.70b
	6hr A	0.71abc	1.06ab	0.83abc	0.87ab
	Average	0.90bc	0.67de	0.77bcde	0.78b
Polyethylene Film	0hr M	0.62bc	0.79abc	0.70abc	0.70b
	6hrA	0.62bc	0.93abc	0.75abc	0.76ab
	Average	0.86bcd	0.62e	0.73cde	0.73b

Zip Lock	0hrM	0.77abc	1.16a	0.94abc	0.96a
	6hrA	0.58c	1.02abc	0.93abc	0.84ab
	Average	1.11a	0.67de	0.94ab	0.91a
(l.s.d 1%)	Packaging material , (l.s.d) = 2.92		CV= 0.11		
	Method of display, (l.s.d) = 2.92		CV = 0.11		
	Packaging Material * Method of Display, (l.s.d) = 2.92				= 0.20

l.s.d = Least significant difference, M = Morning, A = Afternoon, CV = Co-efficient of variation Means with the same letters within a column are not significantly different at 1% using L.S.D.

Statistically, significant ($p<0.01$) difference in TTA was recorded between the treatments (Table 4.36). Fresh-cut sunrise-reddish papaya fruits in zip lock were significantly ($p<0.01$) higher in TTA values than fresh-cut fruits packaged in clam shell as well as polyethylene film (Table 4.36). However, fruits in clam shell and polyethylene were not statistically different ($p>0.01$) in TTA.

Regarding methods of display, significant ($p<0.01$) difference was observed only under hawked condition where the highest and lowest TTA values were recorded by zip lock and clam shell respectively.

The interaction between packaging material and method of display, revealed that hawked fresh-cut sunrise-reddish papaya fruits were statistically different from the shaded fruits as was observed. Thus, fresh-cut papaya fruits that were displayed under hawked condition were significantly ($p<0.01$) higher in TTA values than shaded fruits.

4.7.6 Microbial Load on Freshly-Cut Papaya Fruit Samples

Table 4.37: *Staphylococcus* Count on Freshly-Cut Papaya Fruits

Packaging	**Average Material**		**Method of Display**		
	Time	Hawked	Shaded	Unshaded	
Clam Shell	0hrM	0.28×10^{3}b	0.13×10^{3}b	3.20×10^{3}ab	1.20×10^{3}a
	6hr A	5.20×10^{3}a	1.40×10^{3}ab	1.07×10^{3}ab	2.56×10^{3}a
	Average	2.74×10^{3}a	0.76×10^{3}ab	2.13×10^{3}ab	1.88×10^{3}a

Polyethylene Film	0hr M	0.31×10^3b	0.74×10^3b	0.43×10^3b	0.49×10^3a
	6hrA	0.47×10^3b	1.02×10^3ab	0.56×10^3b	0.68×10^3a
	Average	1.60×10^3ab	1.33×10^3ab	0.88×10^3ab	1.27×10^3ab
Zip Lock	0hrM	2.06×10^3ab	1.68×10^3ab	1.19×10^3ab	1.64×10^3a
	6hrA	1.15×10^3ab	0.98×10^3ab	0.58×10^3b	0.90×10^3a
	Average	0.39×10^3b	0.88×10^3ab	0.49×10^3b	0.59×10^3b
(L.s.d 1%)	Packaging material, (l.s.d) = 2.92 CV= 1161.9 Method of display, (l.s.d) = 2.92 CV = 1161.9 Packaging Material * Method of Display (l.s.d) =2.92 CV= 2012.4				

l.s.d = Least significant difference, M = Morning, A = Afternoon, CV = Co-efficient of variation.Means with the same letters within a column are not significantly different at 1% using L.S.D.

From Table 4.37, all the packaging materials that contained fresh-cut papaya fruits tested positive of *Staphylococcus*. While higher significant ($p<0.01$) counts of *Staphylococcus* on fresh-cut sunrise-reddish papaya fruits were recorded by clam shell, lower counts were obtained by zip lock.

The results also showed that, *Staphylococcus* counts of fresh-cut papaya fruits under the methods of display for hawked, unshaded and shaded conditions was 1.58×10^3 1.17×10^3 cfu/g and 0.99×10^3 cfu/g respectively. However, significant differences were not recorded by shaded and unshaded methods as was observed ($p>0.01$). Contrary, hawked fresh-cut sunrise-reddish papaya fruits exhibited significance with clam sell fruits recording the highest Staphylococcus count and Zip lock recording the lowest count.

The effect of packaging material and method of display revealed that, *Staphylococcus* count of fresh-cut sunrise-reddish papaya fruits were not affected by the treatments.

4.7.7 *E. coli*

Table 4.38: *E. Coli* Count on Freshly-Cut Papaya Fruits

Packaging		**Method of Display**			**Average**
Material	Time	Hawked	Shaded	Unshaded	

Clam Shell	0hrM	2.24×10^3a	1.63×10^3a	3.18×10^3a	2.35×10^3ab
	6hr A	1.32×10^3a	0.70×10^3a	0.43×10^3a	0.82×10^3b
	Average	1.78×10^3a	1.17×10^3a	1.81×10^3a	1.58×10^3 a
Polyethylene Film	0hr M	3.18×10^3a	3.99×10^3a	4.15×10^3a	3.78×10^3a
	6hrA	1.61×10^3a	3.13×10^3a	1.74×10^3a	2.16×10^3ab
	Average	2.61×10^3a	1.48×10^3a	2.63×10^3a	2.24×10^3a
Zip Lock	0hrM	3.22×10^3a	1.65×10^3a	2.72×10^3a	2.53×10^3ab
	6hrA	2.00×10^3a	1.31×10^3a	2.53×10^3a	1.95×10^3ab
	Average	2.40×10^3a	3.56×10^3a	2.46×10^3a	2.97×10^3a
(L.s.d 1%)	Packaging material, (l.s.d) = 2.92 CV= 1443.2 Method of display, (l.s.d) = 2.92 CV =1443.2 Packaging Material * Method of Display, (l.s.d)=2.92 CV=2499.6				

l.s.d = Least significant difference, M = Morning, A = Afternoon, CV = Co-efficient of variation, Means with the same letters within a column are not significantly different at 1% using L.S.D.

Table 4.38 revealed that all the packaging materials were contaminated with E. coli irrespective of the time the fruits were collected. However, no significant ($p>0.01$) difference was recorded. Higher (2.97×10^3 cfu/g) E. coli counts on fresh-cut papaya fruits were recorded by zip lock while a lower (1.58×10^3cfu/g) count was recorded by clam shell (Table 4.38).

In the case of method of display, fresh-cut papaya fruits that were displayed under unshaded condition recorded a higher (2.46×10^3 cfu/g) E. coli count compared to fresh-cut fruits under shade that recorded lower (2.07×10^3cfu/g) E. coli counts.

The interaction between packaging material and method of display revealed that, fresh-cut sunrise-reddish papaya fruits packaged in zip lock displayed under shade and unshaded conditions recorded the highest (3.56×10^3cfu/g and 2.94×10^3cfu/g) E. coli count whiles clam shell recorded the lowest counts (1.17×10^3cfu/g and 1.81×10^3cfu/g) respectively. Fresh-cut sunrise-reddish papaya fruits in clam shell exhibited a specific trend by recording the lowest E. coli count throughout the display methods. However, interaction effect of packaging material and method of display did not significantly ($p>0.01$) influence E, coli count.

Table 4.39: Salmonella Count on Fresh-Cut Papaya Fruits

Packaging Material		**Method of Display**		
	Time	Hawked	Shaded	Unshaded
Clam Shell	0hrM	-	-	-
	6hr A	-	-	-
Polyethylene	0hr M	-	-	-
	6hrA	-	-	-
Zip Lock	0hrM	-	-	-
	6hrA	-	-	-

- = absent

4.8 LABORATORY EXPERIMENT II

4.8.1: Firmness

The results of the effect of packaging material on the firmness of fresh-cut sunrisereddish papaya during the holding period has been reported in Figure 4.6

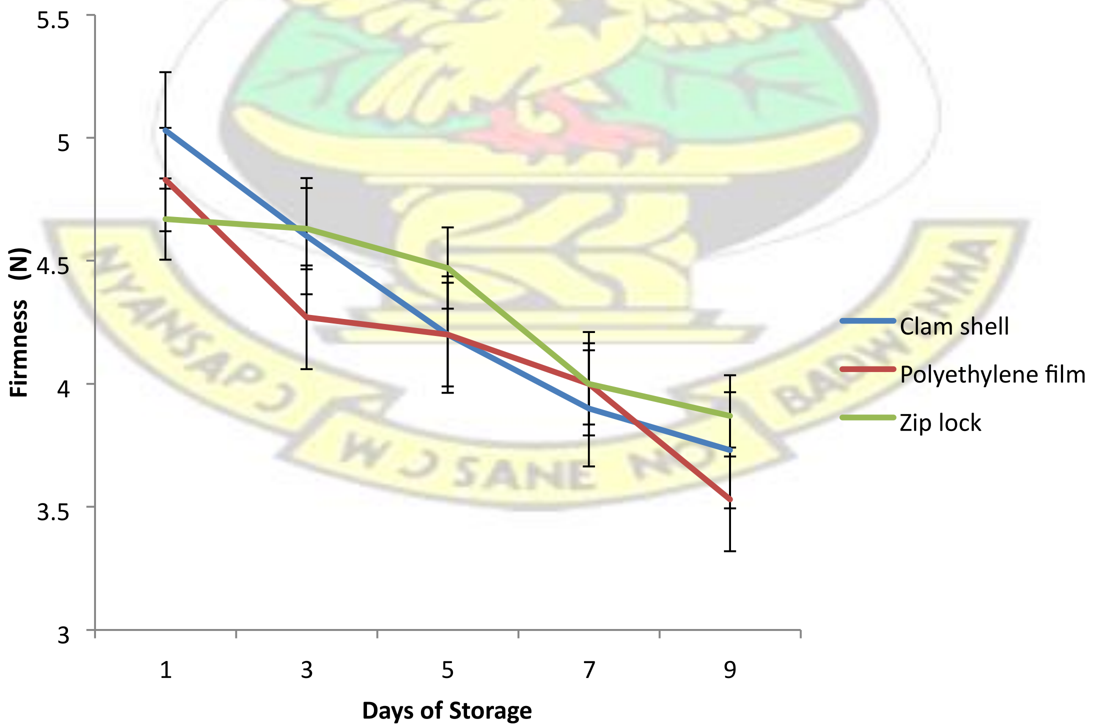

Figure 4.6: Firmness of Fresh-cut Sunrise-reddish Papaya fruits as observed for the Storage days at 5°C.

There was a general decrease in the firmness of fresh-cut sunrise-reddish papaya fruits throughout the storage days at 5°C (Figure 4.6). However, the treatments did not significantly influence the firmness ($p>0.01$). Fresh-cut sunrise-reddish papaya fruit in Zip lock recorded the lowest firmness value on day 1 but subsequently had a firmer value than Polyethylene film and Clam shell as was noticed on days 3, 5 and 9. While fresh-cut sunrise-reddish papaya fruits in Clam shell and Polyethylene film recorded similar firmness value (4.20N) on day 5, Polyethylene film and Zip lock also showed similar firmness (4.00N) on day 7of storage at 5°C (Figure 4.6)

4.8.2: Moisture Content

The results of the effect of packaging material on the moisture content of fresh-cut sunrise-reddish papaya during holding is shown in Figure 4.7

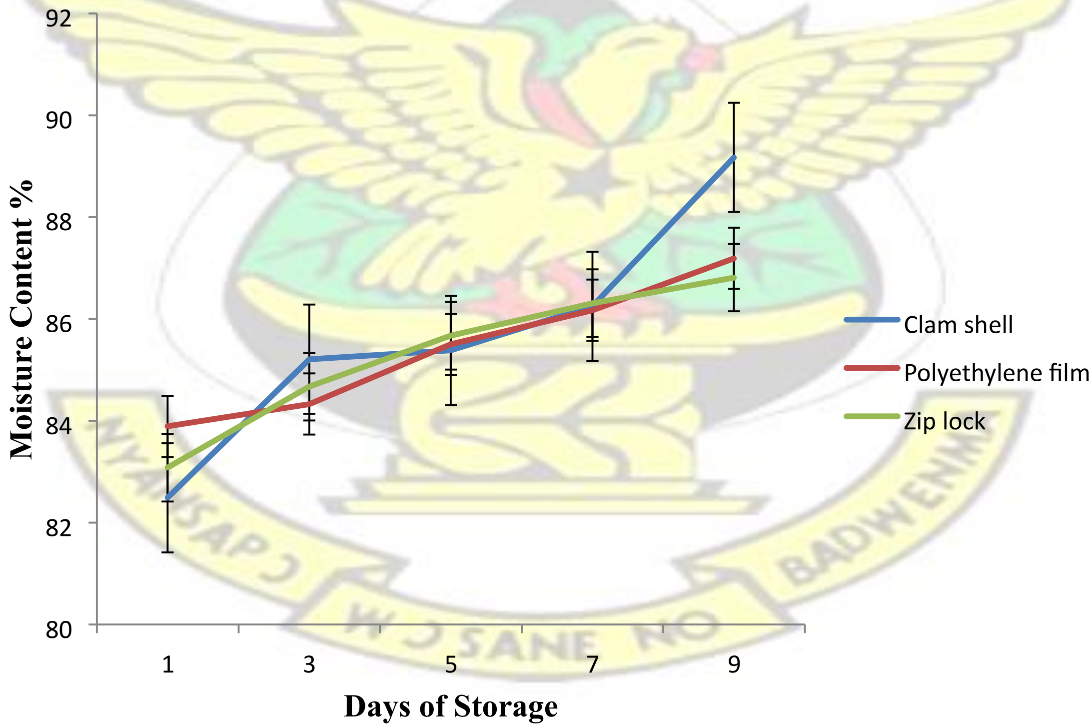

Figure 4.7: Moisture content of Fresh-cut Sunrise-reddish Papaya fruits as observed for the Storage days at 5˚C.

Generally, there was an increase in the moisture content of fresh-cut sunrise-reddish papaya fruits in all the different packaging materials as the days of storage progressed. However, no significant (p>0.01) difference was recorded in the moisture content of fresh-cut sunrise-reddish papaya fruits irrespective of the treatments. Fresh-cut sunrise-reddish papzya fruits in Clam shell recorded the lowest moisture (85.49 %) content on day 1 amongst the packaging materials but however had an increased in moisture content (89.17 %) on day 9 of storage at 5 °C. On days 5 and 7, Zip lock recorded the best moisture vales (85. 67 % and 86.31 %) respectively. All fresh-cut papaya fruits in the packaging materials exhibited approximate moisture content on days 5 and 7 during the storage period (Figure 4.7).

4.8.3: Total Soluble Solids (TSS)

The results of the effect of packaging material on the total soluble solids of fresh-cut sunrise-reddish papaya fruits throughout the study period has been shown in Figure 4.8.

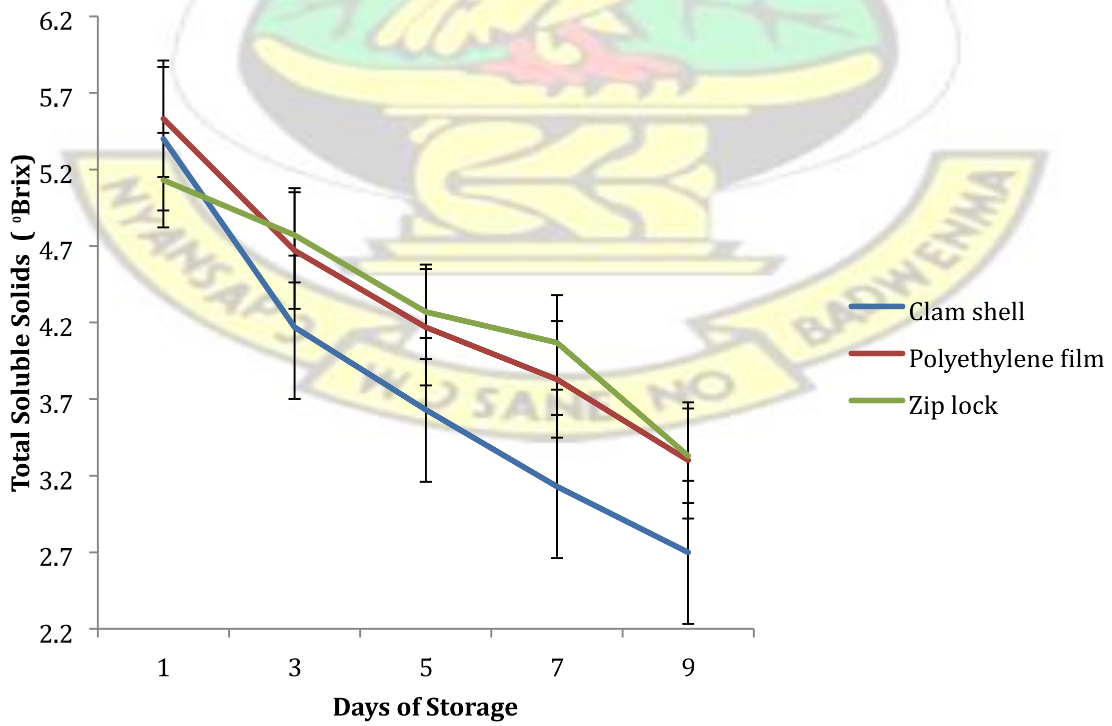

Figure 4.8: Total Soluble Solids of Fresh-cut Sunrise-reddish Papaya fruits as observed for the Storage days at 5°C.

From Figure (4.8), there was a general decrease in total soluble solids of fresh-cut sunrise-reddish papaya fruits in all the treatments as the days of storage progressed. No significant ($p>0.01$) difference was recorded irrespective of the treatments. Freshcut papaya fruits in Polyethylene film exhibited the highest (5.5) TSS value on day 1 but recorded the least value for the rest of the days. Fresh-cut papaya fruits in Zip lock recorded the highest TSS value on days 3, 5, 7 and 9 consecutively. Although fresh-cut papaya fruits in Clam shell had an increased TSS value on day 1 than polyethylene and Zip lock, it recorded the least TSS value for the rest of the days

4.8.4 pH

The results of the effect of packaging material on the pH of fresh-cut sunrise-reddish papaya fruits during holding has been shown in Figure 4.9

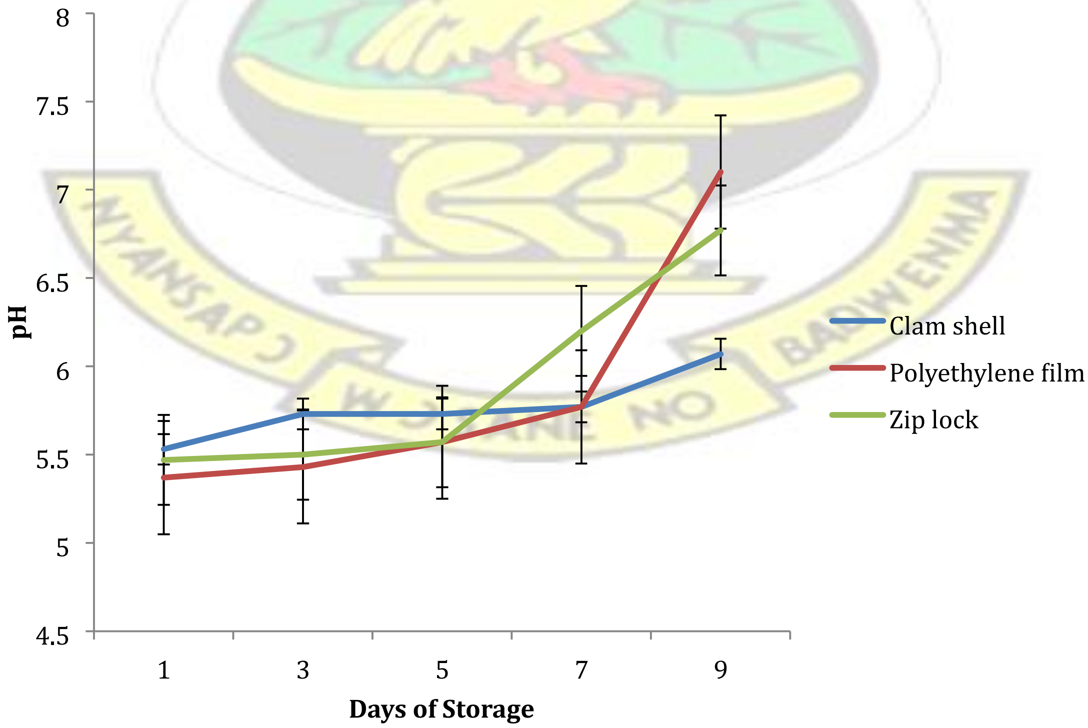

Figure 4.9: pH of Fresh-cut Sunrise-reddish Papaya fruits as Observed for the Storage Days at 5°C.

From Figure 4.9, there was a general increase in pH values of all the treatments during the study period. Significant differences were not recorded for the first 7 days of storage irrespective of the treatments. However, the highest significant (P<0.01) difference was recorded by Zip lock while the least was recorded by Clam shell on day 9. Clam shell had an increase in pH values for the first 5 days of storage at 5°C but however recorded the least pH value on day 9. While Zip lock had a higher (6.20) pH on day 7, Polyethylene and Clam shell recorded similar pH values (5.77)

4.8.5 Total Titratable Acidity (TTA)

The results of the effect of packaging material on the total titratable acidity of freshcut sunrise-reddish papaya fruits during the storage period has been reported in Figure 4.10.

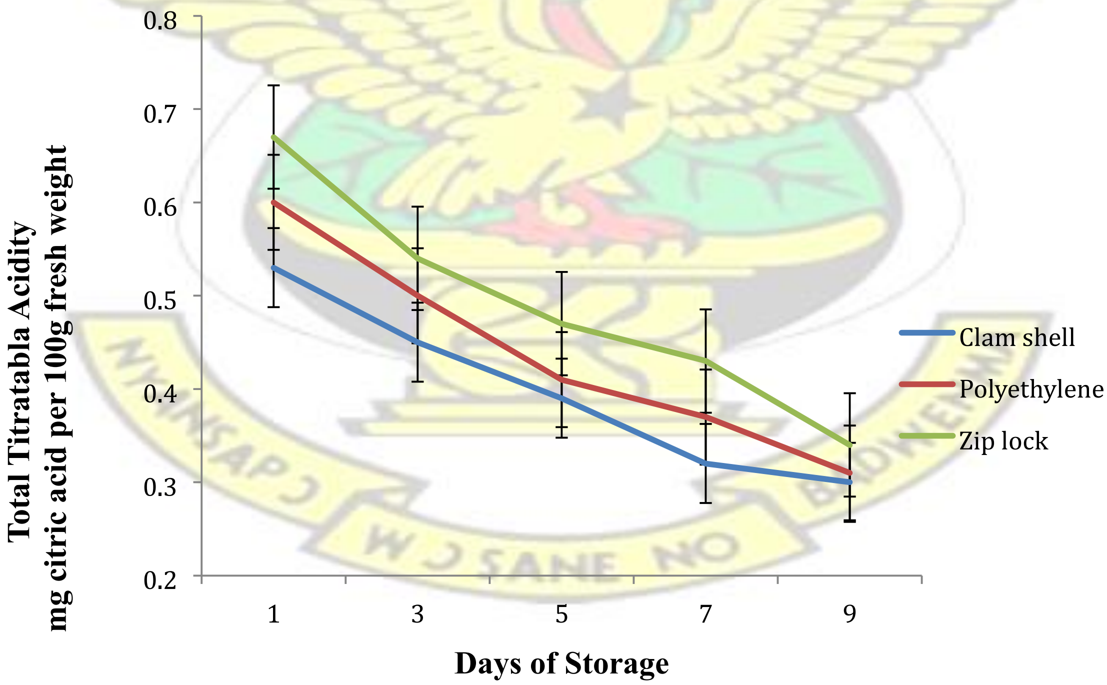

Figure 4.10: Total Titratable Acidity of Fresh-cut Sunrise-reddish Papaya Fruits as Observed for the Storage Days at 5°C.

Generally, there was a decrease in the total titratable acidity of fresh-cut papaya fruits throughout the storage days at 5 °C (Figure 4.10). The decrease in TTA values were approximately constant after 9-d of storage at 5 ° C. The decreases in TTA were 43.4 %, 48.3 % and 49.3 % by Clam shell, Polyethylene film and Zip lock respectively. However, no significant (p>0.01) difference was recorded irrespective of the treatments. Zip lock exhibited a specific trend as it recorded the highest TTA values for all the storage days under consideration.

4.8.6 Shelf-Life

4.8.6.1 Colour

The results of the effect of packaging material on colour of fresh-cut sunrise- reddish papaya fruits during the storage period has been reported in Figure 4.11

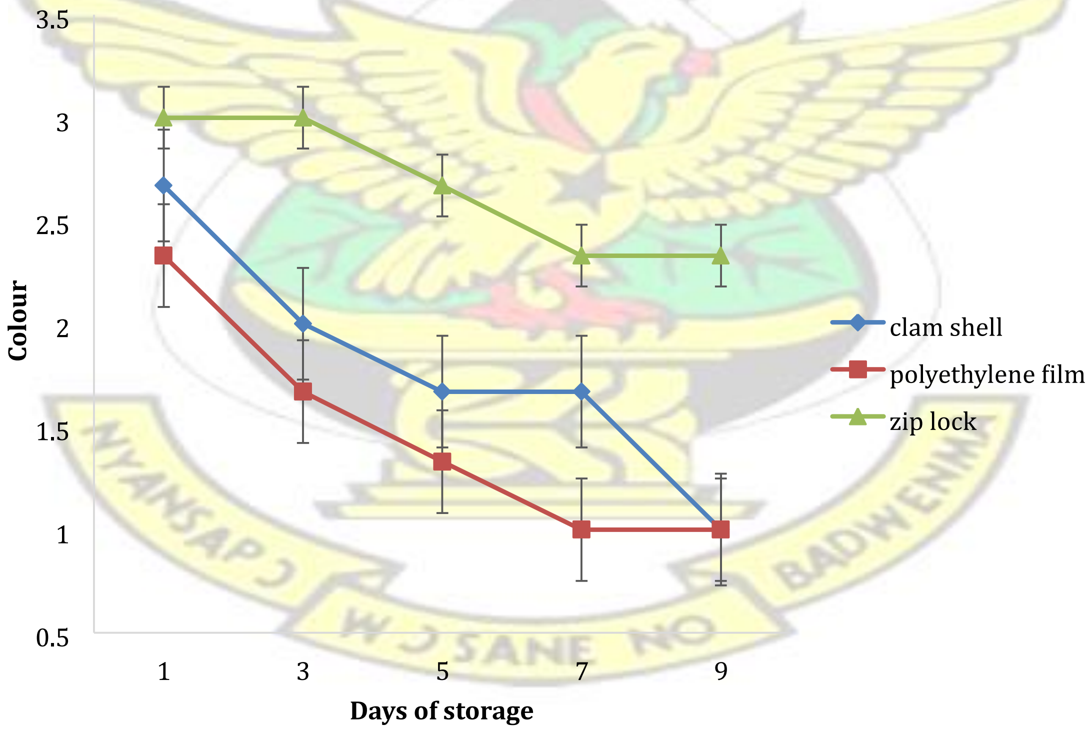

Figure 4.11: Colour Score of fresh-cut Sunrise-reddish Papaya fruits as observed for the Storage days at 5°C

Generally, there was a decrease in the colour score of fresh-cut sunrise-reddish papaya fruits as they days advanced irrespective of the treatments (Figure 4.11). While fresh-cut fruits in Clam shell and Polyethylene had a decrease in the colour score on day 3, fresh-cut fruits in Zip lock maintained its colour but subsequently experienced a sharp decrease in colour score on day 5. The results revealed that a higher significant (p<0.01) colour score was recorded by Zip lock throughout the storage days after day 3 relative to Polyethylene film which recorded a lower colour score. However, Clam shell and Polyethylene recorded the same colour score on day 9 compared to Zip lock that still maintained a good colour score.

4.8.6.2 Aroma

The results of the effect of packaging material on aroma of fresh-cut sunrise-reddish papaya fruits during the storage period has been reported in Figure 4.12

Figure 4.12: Aroma Score for Fresh-cut Sunrise-reddish Papaya fruits as observed for the Storage days at 5°C.

From figure 4.13, no significant ($p<0.01$) difference was recorded on the aroma of fresh-cut sunrise-reddish papaya fruits as the days progressed (Figure 4.12). However, fresh-cut papaya fruits in Clam shell and Zip lock recorded similar aroma score throughout the storage days. Fruits packaged in Polyethylene recorded a higher aroma score on day 1 subsequently recorded a reduction which was maintained throughout the storage days.

4.8.6.3 Texture

The results of the effect of packaging material on colour of fresh-cut sunrise-reddish papaya fruits during the storage period has been reported in Figure 4.13

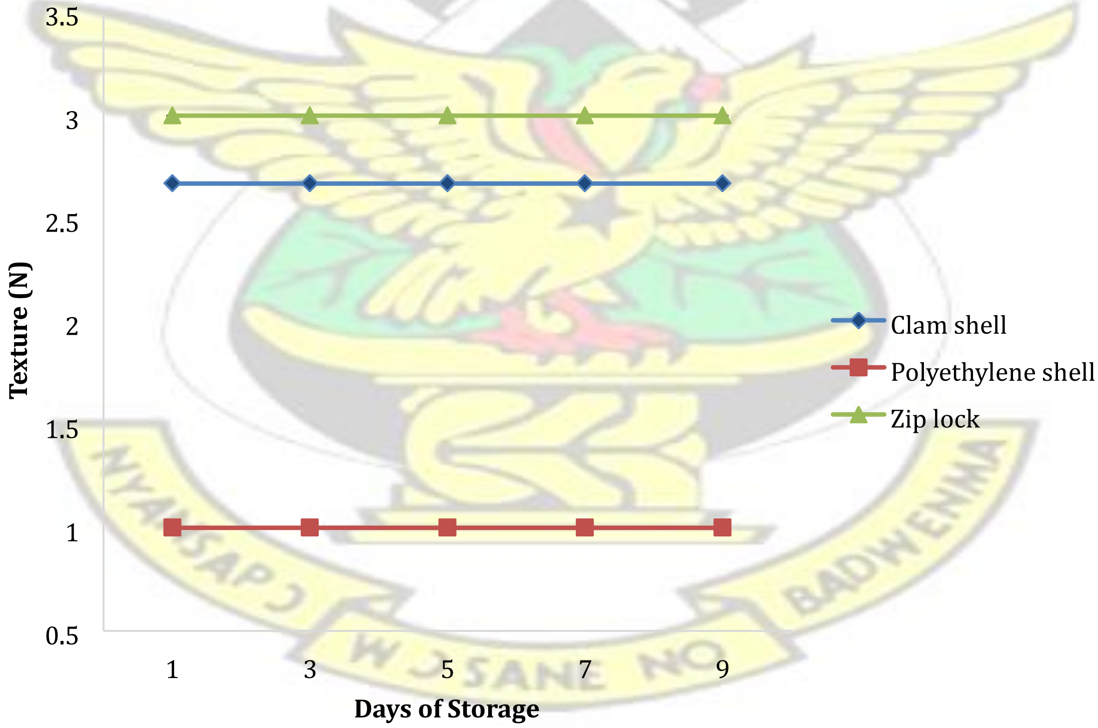

Figure 4.13: Texture Score of Fresh-cut Sunrise-reddish Papaya fruits as observed for the Storage days at 5°C

From Figure 4.13, fresh-cuts sunrise-reddish papaya fruits in each of the packaging materials recorded and maintained almost the same texture score throughout the storage days of the study. No significant (p>0.01) difference was recorded between the texture score of fresh-cut papaya fruits packaged in Clam shell and Zip lock. However, the results revealed that fresh-cut papaya fruits in Clam shell and Zip lock throughout the storage days were significantly (p<0.01) higher in texture score compared to polyethylene film (Figure 4.13).

4.9.1 Microbial Load

4.9.1.1 *Escherichia coli* (E. coli)

The results of the effect of packaging material on *E. coli* count of fresh-cut sunrisereddish papaya fruits during the storage period has been reported in Figure 4.14

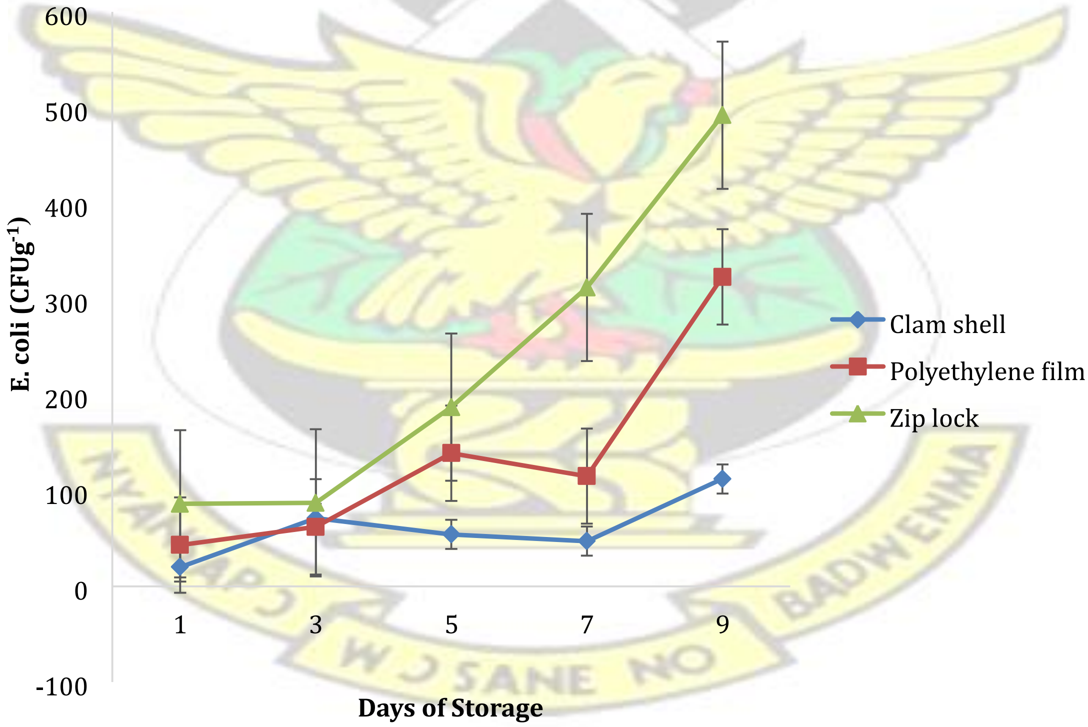

Figure 4.14: *E. coli* count of Fresh-cut Sunrise-reddish Papaya fruits as Observed for the Storage days at 5°C

Generally, all the treatments recorded an increase in the counts of *E. coli* on day 3 with a subsequent decrease in counts in Clam shell and Polyethylene on days 5 and 7 (Figure 4.14). Counts of *E. coli* on fresh-cut papaya fruits in Zip lock were significantly ($p<0.01$) higher than counts in Clam shell on day 7. Again, all the treatments recorded an increase in *E. coli* count after day 9storage at 5°C. However, no significant difference ($p>0.01$) was recorded in *E. coli* count during the first 5 days of storage at 5°C. ZIP lock exhibited a specific trend as there was an increase in *E. coli* count throughout the storage days.

4.9.2 *Staphylococcus*

The results of the effect of packaging material on *Staphylococcus* count of fresh-cut sunrise-reddish papaya fruits during the storage period has been reported in Figure 4.15.

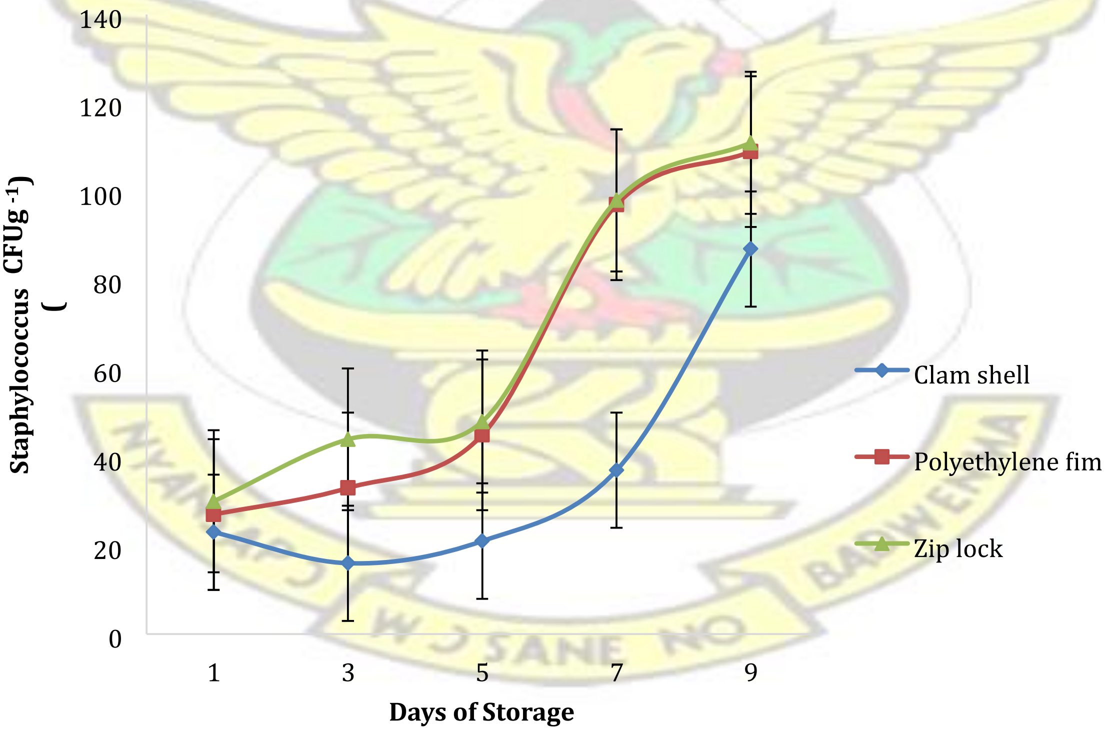

Figure 4.15: *Staphylococcus* of Fresh-cut Sunrise-reddish fruits Papaya as observed for the Storage days at 5°C

Figure 4.15 shows that there was generally an increase *Staphylococcus* counts in all the treatments. Whiles Polyethylene film and Zip lock recorded an increase in *Staphylococcus* count on day 3, Clam shell recorded a decrease. However, all the treatments were not significant ($p>0.01$) throughout the storage days at 5°C. Table 4.40: *Salmonella* Count of Freshly-cut Papaya Fruits Stored at 5°C

Packaging Material	**Days of Storage at 5°C**				
	1	3	5	7	9
Clam shell	-	-	-	-	-
Polyethylene film	-	-	-	-	-
Zip lock	-	-	-	-	-

- = absent

5.0 DISCUSSION

5.1 Introduction

The chapter discusses the results of the data gathered from the market survey. Crossreferences are made between issues reported by the consumers to that of the retailers where appropriate. The discussion also, draws inferences from literature in an attempt to compare the results of the study to earlier works.

5.2 Discussion of Field Survey Results

5.2.1 Trade and Consumption of Papaya in the Ashanti Region

The Ashanti region is the second largest region in Ghana after the Greater Accra region in terms of population. This provides a large market for goods and services including agricultural produce. Therefore, a good patronage of papaya fruit would boost the production and consumption of the fruit thereby increasing income of producers and retailers. Consequently, employment and income generating opportunities would be created to support people engaged in the sector.

According to Mashahudu (2009), papaya fruits provide substantial income at both the micro and macro levels of Ghana's economy. From the study, the papaya retail business provided a vital source of livelihoods for populace engaged in the industry. It was the main business for over 66 percent of the actors who were mainly females. Like other small scale informal sector business, the papaya retail trade required very little capital and skill to engage in the business. As a result, the sector provided a way out of unemployment for the retailers who previously had no jobs. It therefore served as a vital source of income for some households in the Kumasi Metropolis. This implied that the papaya retail business like other petty trading activities has the propensity to reduce unemployment and enhance the living conditions of the populace engaged in the business.

However, the seasonal fluctuation in the availability of the fruit affected both the trade and consumption of the papaya fruit. For the retailers, switching to other fruits such as mangoes and apples was vital to stay in business. This was mainly because the papaya fruits became very expensive and difficult to obtain during off season periods. This translated into high retail prices which made it difficult for consumers to purchase. During the survey, majority of consumers were found to consume papaya occasionally. This according to the consumers was due to the expensive nature of the papaya fruits when it was off season.

The average number of fruits peeled and packaged at a time was 4 fruits. Once peeled and packaged, it took the retailer about 20 minutes to sell out the packaged fruits and proceed to package the next round of fruits. Throughout the day, a retailer processed and sold 50 fruits on the average. This implied that once processed, fruits are kept for about 20 minutes before consumption. As indicated earlier, the processed fruits were not kept under any controlled temperature; hence the rate of decomposition was normally high. As reported by Soliva-Fortuny and MatinBelloso (2003), this situation presented a major obstacle to the papaya retail trade as it affected the quality and shell life of the fruit.

5.2.1.1 Marketing / Sale and Consumption of Papaya Fruits

The papaya market as part of the agricultural sector offers employment opportunity for a substantial number of people especially females. Actors in the value chain of the papaya production, distribution and final sale are offered an opportunity to earn some income to sustain themselves and families. Reports from literature indicate growing demand for fresh-cut fruits globally (Bernardelli, 2005). Analysis of the consumption regularity of papaya among respondents revealed that despite the substantial nutritional value of papaya, most people consumed the fruit occasionally. Over 70 percent of the consumers interviewed reported consuming papaya occasionally. The main reason for occasional consumption of the papaya fruit was the fact that the fruit was only available during some times of the year. Also, when the fruit was not in season, it was expensive to buy hence low income individuals could not afford the fruit. Similarly, most retailers often switch from trading in papaya to other fruits when the fruit was not in season. This was due to scarcity of the fruit and high cost of acquiring it during offseason periods.

The sunrise, reddish-orange papaya fruit variety, was the most patronized variety of papaya by retailers for sale. This correlated with the consumers taste and choice of variety. About 55 percent of consumers who patronized the reddish-orange variety attributed their choice to the sweet taste of the variety. Also, 39 percent of consumers preferred the kapoho, yellow-orange variety while 6 percent patronized both varieties. Other reasons which influenced consumer preference of variety included the texture and the smell of the fruit.

Majority (60 %) of the consumers bought the fruit from both retailers stationed under shade and hawkers/mobile retailers. However, many more consumers patronized papaya from retailers located under shade (24 %) than retailers who hawk (16 %) in the open sun. Despite the possible damage to the quality of processed papaya fruit when exposed to direct sunlight and other weather conditions, the general statistics on the point of sale of papaya fruits bought by consumers indicated that most consumers were not very particular about the place where the fruit was sold. Majority (95 %) of the retailers openly displayed the packaged fruits on trays. The tray was placed on a raised platform, mostly tables or carried on the head in the case of the mobile retailers. However, some of the retailers displayed the packaged fruits on bare tables.

The decision to buy papaya from a given retailer was found to be influenced by the affordability, appearance of packaging and other factors including the variety and ripening stage being sold. The attractiveness of the packaging in which the processed fruit was sold was the most important determinant in the consumer's demand decision. About 48 percent of the consumers alluded to the nature of packaging as the main factor they considered in buying processed papaya fruit from a retailer. This group of consumers preferred a nicely packaged fruits which they believe was hygienic and good for consumption. Affordability of the fruit accounted for 21 percent of the decision to buy from a given retailer. The remaining 31 percent of the consumers mentioned other factors such as availability and proximity to retailer which serve as the basis for their choice of retailer from where to buy process papaya fruits.

5.2.1.2 Expenditure and Income of Fresh-cut Papaya Fruit Retailers

The papaya fruit retail business was generally done on small scale. An average amount of GH¢50 is expended daily by a retailer in buying papaya fruits for sale. It was revealed that retailers usually purchased papaya on daily basis. The retailers attributed this practice to the perishable nature of the produce which made it risky to buy in large quantities and stock for longer periods. It was observed that the highest amount spent by retailers in buying the produce was within the range of GH¢70 to GH¢100 daily. It was also observed from the market survey that it was a common practice to see two or more retailers jointly buying and sharing a bag of papaya fruits from the wholesalers. The reasons for this practice were that some retailers could not afford a whole bag coupled with the fact that it was often difficult to sell out a whole bag within a day.

The fruit was peeled, sliced and packaged into varied quantities which were sold for GH¢1, GH¢1.5 And GH¢2 depending on the quantity in the package. However, when the fruit was not in season thereby scarce to obtain, the quantity which was sold for GH¢2 could be sold for GH¢5 or more. It was observed that about 87 percent of the consumers interviewed reported of buying the GH¢1 package. As observed on Table 4.12, affordability was an important factor that influenced consumer demand for processed papaya fruits.

Income

A large proportion (70 %) of the retailers reported of profit margins between GH¢8 and GH¢15 daily. About 42 percent earned profit of GH¢10 or less. Retailers who made profits above GH¢15 daily constituted about 26 percent of the respondents interviewed (see Table 4.15).

The research also attempted assessing the amount of losses made by retailers in their businesses daily. It was observed that about 84 percent of the retailers experienced daily losses to the sum of GH¢10 or less. A significant number constituting 12 percent of the retailers experienced financial losses between GH¢16 and GH¢20 daily (see Table 4.16). Losses were mainly due to unfinished daily stock which the retailer could not sell during the day.

5.2.3 Sourcing and Handling of Papaya

As explained earlier, the sunrise had a relatively larger patronage than the Kapoho Fruits were mostly harvested and sold in two maturation stages. These were at the breaker stage and at half ripe stage. From Table 4.18, majority (74%) of the retailers reported that they purchased and sold both breaker and half ripened papaya fruits. However, 14 and 12 percent of the retailers traded in only breaker and half ripened fruits respectively. At these two maturation stages, the fruit maintains a relatively longer shelf life as compared to the fully ripe and over ripen fruits. The retailers further added that most consumers prefer the breaker and half ripe fruits due to the nice and less sugary taste and crisp texture.

Handling of Papaya Fruits

Aside the maturation stage at harvest, transportation duration and storage methods after harvest are important variables that impact the shelf life of the papaya fruit. Transportation step conveys the produce from the growing region to the selling region. From the analysis, the average distance between the source of papaya and sale point was about 3.3 kilometers. From Table 4.19, 94 percent of the retailers travel between 1 and 5 kilometers to buy their papaya fruits. Retailers mainly traveled to major market centres such as the Bantama market within the Ashanti region to buy the fruits from the wholesalers. Wholesalers traveled to much far distances to buy the fruits. Analysis of the survey results indicated an average of 30 kilometers travel covered by wholesalers to purchase papaya from the farm gate.

The average time taken to convey the fruits from the farm gate to the market was 3 hours. Research available points out to the fact that there should be a reduction in the kilometers a food product travels from harvest to market (Pretty *et al.,* 2005). This could have contributed to the losses that the wholesalers had invariably experienced upon arrival. This is reiterated by Crisosto *et al*. (1995) who reported that during transportation, physical damage result from loading, unloading and stocking operations or from shock and vibration. About 80 percent of the wholesalers reported using about 3 hours whiles the remaining 20 percent used more time to transport the fruits to the market centre. During this period, the fruits are not kept under any control temperature condition to help prolong their shelf life. Shelf life can be prolonged by maintaining a produce at its optimal temperature, relative humidity and environmental conditions (Shewfelt, 1986; Lee and Kader, 2000). This implied that implementing measures to enhance the shelf life of the fruits would be very effective when both wholesalers and retailers are involved.

Majority (98 %) of the retailers usually purchases the papaya fruit in the morning while the remaining 2 percent do so in the evening (see Figure 4.1). The wholesalers interviewed also alluded to carting the fruit to the market and selling them in the morning. According to the traders, the low heat and relatively cool temperature conditions during these hours of the day, especially during the morning, helps prolong the shelf life of the fruits.

After harvest, papaya fruits are usually processed and consumed within 48 hours as revealed from the study. All the wholesalers usually sell their fruits within a day. Similarly, majority (64 %) of the retailers reported of selling out their fruit within a day. However, about 36 percent of the retailers reported of storing the fruit for a maximum of one day. The unprocessed fruits, according to these retailers, are kept in an airy area where there is less heat. This is to slow the ripening rate of the fruits. Only 1 out of the 50 retailers stores her fruits in a refrigerator. It could therefore be concluded that the actors in the papaya fruit distribution chain lack the requisite storage facilities hence they resort to buying and selling small quantities on daily basis.

Aside lack of proper storage facilities, the papaya traders also lose some of the fruits during transportation. The survey revealed that a relatively large quantity of fruits are damaged or bruised during the carting from the farm gate to the market. These damages reduce the shelf life of the fruits. From Table 4.22, about 90 percent of wholesalers therefore lose between 1 and 2 bags of fruits. Using the average of 100 fruits per bag, it implies that a wholesaler loses about 200 fruits due to damage during the freight. However, majority (91 %) of the 43 retailers who complained of damaged fruits had less than 6 fruits damaged during transportation. This implies that proper handling of fruits during freighting is essential to maintaining the shelf life and quality of fruits.

5.2.4 Processing and Packaging of Papaya

Retailers adopt simple methods and equipment in processing and packaging papaya fruits for sale. After the fruits are purchased from the wholesalers, cold water is used in rinsing the fruits before they are peeled and packaged. Some retailers use water together with sponge to clean the fruits. According to the retailers, pipe water is used for the cleaning. Macsuga (2007) reported that, portable water is an important requirement for washing the produce. The purpose of the washing is to remove soil particles and other debris from the fruit before cutting. Some of the retailers added salt as a sterilizing agent for cleaning the fruits. From the responses of the consumers, about 53 percent confirmed that retailers use water in washing the fruits whereas the remaining 47 percent had no idea about the material or method used in cleaning the fruits before cutting.

After cleaning and peeling, the fruit is chopped into various shapes like cubes or rectangular slices. This was done using sharp kitchen knives. Hundred (100) percent of the retailers cleaned the cutting tools (knife) used in peeling and cutting the fruits. Majority (95 %) of the consumers believed that the cutting tools are washed prior to processing of the papaya fruits. With reference to literature, the retailers' failed to adopt proper process in ensuring that the quality of the fruits were maintained placed consumers at risk of eating contaminated fruits. Moreover, none of the retailers had proper training on how to handle fruits. Furthermore, no checks were done on the water or chemicals like chlorine added to ensure that the water was clean enough to prevent contamination of the fruits. However, it is important to note that consumers' decision to buy processed fruits generally gave little consideration to whether the retailer sterilized that cutting equipment or not.

It was found from the survey that the retailers' choice of packaging material was informed by three major factors. The main determinant was the level of affordability which accounted for over 59 percent of the choice of packaging material used by retailers. The other two were the attractiveness and the kind of material preferred by most consumers. Some retailers also reported that their choice of packaging material was largely based on the materials that are commonly available. It is important to note that safety and hygienic conditions associated with a given packaging material were not important considerations among the retailers. Also, the effect of a given packaging material has on the shelf life of the fruit was not mentioned by any of the retailers in terms of the factors they considered in choosing a packaging material. This situation could be attributed to the fact that the retailers had little knowledge on the possible effect various packaging materials had on the fruits. Another reason was the fact that none of the retailers had any form of training on how to properly handle fruits.

The study has demonstrated that, generally, the packaging materials currently used by the retailers have various effects on the quality of the papaya fruit. These retailers however expressed their willingness to adopt better packaging methods and materials to enhance the shelf life of their fruits and the attractiveness and profitability of their business. About 98 percent of the retailers said they were willing to accept and use better packaging material if they are introduced to such material. The remaining two percent however were resistant to changing from their current packaging material to a different one. This was based on their express fear of high cost of such packaging material coupled with their confidence in the packaging material they were using. It could therefore be concluded that there is the need to provide the customers with quality fruits. Therefore the retailers would adopt improved methods of processing and packaging their products.

5.2.4.1 Challenges in the Papaya Packaging and Retail Business

The papaya fruit traders faced some challenges in conducting their business. In transporting fruits to destination markets, some fruits get damaged. This causes retailers to incur losses which affect their profit margins. The situation is further compounded by lack of proper storage facilities for storing and enhancing the shelf life of fruits before and after processing. Generally, the retailers are unable to afford such facilities due to low capital used in starting and running their businesses. The study revealed that over 70 percent of the retailers did not have ready market for the fruits. This could be attributed to most consumers buying processed papaya occasionally. Because most retailers lack storage facilities to store unsold fruits, traders often dispose of or gift fruits to relatives. This was explained as a major challenged, to the retailers who as a result were sometimes unable to recoup their investment due to poor market demand.

Engagement in the papaya retail business was mainly influenced by unemployment and low capital required in starting the business. Most of the retailers had little knowledge and skills on handling and preserving the fruit before engaging in the business. This limited the extent to which retailers applied improved handling and storage practices. As a result, retailers openly displayed processed fruits to directly sunlight and high temperature conditions. This affected the shelf life and quality of the fruits as explained by Paull *et al.* (1999).

Similarly, retailers had little knowledge on how different packaging materials impact on the shelf life and taste of the fruit. This was made clear by the fact that most retailers selected their packaging materials based on affordability, attractiveness and what is most preferred by the consumer. Little or no consideration was thereby given to the suitability of the packaging material in preserving shelf life. It was also reported that some of the packaging material such as the polythene film had adverse health implication for consumers.

5.2.5 Effect of Packaging on Papaya Quality and Sale

Consumers demand for a given good/service is usually influenced by certain factors. For the consumers of packaged papaya fruits, time, convenience and attractiveness were identified as the most important reasons for patronizing the product. Already prepared and packaged papaya fruits is said to be time saving and convenient to consume. These factors accounted for about 80 percent of patronage of the packaged fruits. Twenty (20) percent of consumers however patronized the packaged fruit due to the attractive nature of the packaging.

The quality of papaya can be affected by the processing, packaging and exposure of the fruit. As explained earlier, retailers usually process, package and sell the papaya fruit within a day. Plain polythene bags were the common packaging material used by the retailers. Some also use plastic disposable bowls to package the fruit. The package fruit was hawked or sold in the open sun by over 80 percent of the retailers.

This exposure to high temperatures for long period, as espoused in literature, affects the texture (firmness and crisp nature) and the shelf life of the fruit. Less than 20 percent of the retailers were however found to operate under a shade. The selection of a given packaging material by the retailers was based mainly on its attractiveness and the patronage by consumers. It was noted however that retailers had very little or no knowledge on the effect the chemical composition of the package had on the selflife and even quality of the fruits. As expressed by Cortez (2004), the inability for retailers to choose packages to suit the nature of the fruit could adversely affect the self-life of the papaya fruit. Appropriate packaging of fresh cut fruits and vegetables help increase their self-life. Aside being attractive to consumers, packaging protects the fruit from physical damage and microbial contamination. From the study results, the type of packaging largely influenced consumers' decision to buy fresh cut papaya fruits. According to the consumers, packaging had both positive and negative impacts on papaya fruits. The consumers identified certain qualities of the papaya fruit that were affected by packaging mainly as a result of the type of packaging material used and the way packaged fruits were handled by retailers. Comparatively, packaging was perceived to have a more positive impact on retailed papaya fruits. It was found out that majority of the consumers (80 %) were of the opinion that packaging had positive effect on one or more aspects of processed papaya. This was especially true with respect to the fact that packaging of the fruit made it convenient for consumers.

The study also illustrated that packaging of papaya in some instances affected its texture and taste. This was reported by the consumers who also opined that the physic-chemical properties of the papaya fruit are affected by packaging. They believed that packaging makes the fruit lose some of its nutritional quality. Some other effects mentioned by the consumers included health hazards imposed on consumers due to dangerous chemicals introduced into the fruit from the packaging materials (specifically, polythene bags) and contamination due to poor hygienic conditions under which the fruits are prepared and packaged.

As a result of the above mentioned reasons, consumers sometimes complain of unsatisfactory quality of papaya fruits. Among the 50 retailers interviewed, 34 percent of them alluded to ever receiving complaints from consumers about the quality of the packaged fruits. Poor texture quality was a common complaint received by retailers. Inquiring from the consumers, they explained that sometimes fruits were overly soft textured and/or of poor taste. Some consumers reported of experiencing diarrhoea and stomach pains from consuming packaged papaya fruits. As reported by Boshra and Tajul (2013), some of these effects experienced by consumers could be attributed to some of the inherent laxative and other properties of the papaya fruits. This further give credence to Adebiyi *et al.* (2003) call for attention to be paid to the possible side effects that the papaya fruit could have on various individuals based on their report that in India pregnant women are not allowed to eat it due to some potential side effects.

Some consumers were of the view that the packaging had some negative effects on the processed fruit. Among the negative effects mentioned was poor hygiene due to handling coupled with dangerous chemical composition of the packaging material that posed adverse health impacts on the consumer. Some also felt that there was the need for improvement in the packaging to make it more attractive. Four out of the 100 consumers also believed that the texture and taste of the fruits was adversely affected. It could therefore be concluded that though packaging had positive effects on the trade and consumption of the papaya fruits, there was the need for improvement on the packaging process and materials used. Improvements should target the attractiveness, hygiene and the impact of the packaging on fruit taste and texture.

5.3 DISCUSSION OF RESULTS FROM EXPERIMENT I

5.3.1 Firmness

During fruit ripening there is a good relationship between ripening, respiration, ethylene production, and skin colour and wall-degrading enzymatic activity. Paull *et al*. (1999) revealed that, there is a relationship between Peptidoglycan and xylanase and fruit softening. Therefore these enzymes reach their peak when the fruit has 40 to 60 % skin yellowing. Firmness of fresh-cut sunrise-reddish papaya fruits was higher in Clam shell compared to a lower firmness that was recorded by fresh-cut papaya fruits in Polyethylene film (Table 4.32). This could be attributed to the different temperatures and individual characteristics of the packaging materials coupled with methods of display impacted on the fruits. According to Schlime and Rooney (1994) Clam shell and Polyethylene film are described as being high density polyethylene and low density polyethylene respectively and therefore transmits oxygen, carbondioxide and water vapour at different rates. Moreover, the authors explained that the type of polymer from which they are made from, exhibit different enzymatic activity, permeability of gases within the package and its environment as well as respiration rate. The decrease in firmness was in line with similar findings by Aneesh *et al*. (2007) who reported that different temperatures and packaging materials are effective in the ripening of tomatoes resultantly decreasing the firmness score. The increase in firmness of fresh-cut sunrise-reddish papaya which was recorded in Clam shell (Table

4.32) might be attributed partly to the packaging material, shade under which the fruits were displayed as well as a decrease both PG and in polyuronide solubilisation that retarded the firmness decrease. Modified Atmosphere Packaging of fruits help to lower the respiratory activity, delay ripening and softening and reduce the physiological disorders and decay-causing pathogens (Kader, 2004).

The result also revealed that hawked fruits recorded a higher significant firmness value relative to a lower significant firmness value which was recorded by unshaded fruits (4.32). This trend could be attributed to the mobility of the retailers under hawked conditions leading exposure to varying temperatures compared to unshaded conditions that are stationary and without shade. Therefore the rate of enzymatic hydrolysis of cell wall components was presumably enhanced in Polyethylene film, leading to more electrolyte leakage that favoured metabolic activity.

5.3.2 Moisture Content

Averagely, fresh-cut sunrise-reddish papaya fruits in Polyethylene film recorded the highest moisture content whiles Clam shell recorded the lowest moisture content (Table 4.33). This could be partly due to the types of polymers in which these packaging materials are made from coupled with their different characteristics they impact on fresh-cut fruits. As such, the processing activities that included peeling, cutting, deseeding contributed to moisture loss prior to packaging into the different materials. The high moisture content in the fresh-cut sunrise-reddish papaya fruits is in line with the report of USDA (2008) that stated that, the moisture content in papaya fruits ranges from 85-92 %.Therefore, the higher moisture content of freshcut fruits in Polyethylene film recorded in the present study could be due to the accumulation of more water in it that created a high humid environment retarding transpiration and water loss relative to Clam shell as well as Zip lock. The results also revealed that hawked fruits had higher average moisture content than shaded fruits. This could be due to the fact that hawked fresh-cut papaya fruits are exposed to different temperatures during retailing since retailers are invariably mobile and fruits not shaded from the sun whereas shaded fruits are stationary and partly protected from the sun. This give credence to Jacxsens *et al.* (2002) who reported that respiration rate is affected more by temperature fluctuations than film permeability to oxygen and carbon dioxide. Therefore any change in temperature will affect the rate of respiration and the equilibrium conditions within the package unless the rate of diffusion of gas through the film is changed by temperature to exactly the same extent as respiration. A decrease in the internal concentration of CO_2 within bulky plant organs in response to an increase in texture has been repeatedly been demonstrated in for various commodities including papayas and banana (Leonard and Wardlaw, 1941). Respiration roughly doubled or tripled for every rise in o 10 °C and permeability of film has been reported to rise from two to five times with every 10 °C increase in temperature.

The low moisture content value recorded could be attributed to the shade under which the fruits were sold, high water loss, respiration and above all high metabolic activity in the respective packaging materials. Zagory and Kader (1988) reported weight loss of papaya mainly due to moisture loss by transpiration and loss of carbon reserves due to respiration. Gradual reduction of the rates of weight loss was probably due to saturation of atmosphere within the packages by water. Water loss occurs because of a water vapour pressure gradient and high relative humidity could be effective in minimizing water loss (Kader, 1993)

5.3.3 Total soluble Solids (TSS)

The total soluble solids denote a rough measure of the amount of sugars present in the fruits. The increased in TSS during ripening is associated with the degradation of polysaccharides to simple sugars thereby causing a rise in TSS (Naik *et al*., 1993). A higher TSS value was recorded by fruits packaged in Polyethylene film while Zip lock fruits recorded a lower TSS as was observed (Table 4.34). This could be partly due to the different packaging materials and the different metabolic activities in them. These results are in agreement with Park *et al*. (2004); Jeong *et al.* (2005) and Nei *et al*. (2005), they reported that TSS of tomatoes increased at different temperatures and packaging materials.

An average high and low TSS value of fresh-cut sunrise-reddish papaya fruits was recorded by shaded and hawked methods of display respectively (Table 4.34). Therefore the high TSS value could be attributed to the micro climate found within the shade environment relative to varying temperatures obtained by hawked condition. This, however, might have influenced the different metabolic activity coupled with the individual characteristics of the packaging materials. It has been observed in several fresh-cut fruits that peeling and cutting increases the respiration rate from 1-fold to 7-fold, compare with the same whole fresh fruit. It has been reported by numerous researchers that there is a correlation between TSS reduction in sugar content and high metabolic activity when fruits are stored at high temperatures (Chan, 1979). The first substrates used during respiration are sugars, and this could be the main reason that caused the high TSS value which was recorded by shade fruits and a low TSS value by hawked fruits. The present study is therefore in line with research findings by Kim *et al.* (1993) and Texeira *et al*. (2001) that the respiration rate of fresh-cut tomatoes was affected by both storage temperature and cutting shape. The findings of the present study are also in conformity with Shela and Masud (2007) and Abdullah *et al.* (2004) who also reported that TSS of tomatoes increased at different stages, temperatures and packaging materials.

5.3.4 pH pH is an indicator of the amount of acidity or alkalinity present in a product. Thus, it is used to primarily estimate the consumption quality as well as hidden attributes. The present study recorded an average pH of 4.26 by the packaging material (Table 4.35). From the study, fresh-cut sunrise-reddish papaya fruits in Polyethylene film recorded a higher pH value which was contrasted by a lower pH by fresh-cut fruits in Zip lock. This could be partly due to the different polymer characteristics of the packaging materials and the breaker stage that the fruits were obtained. Salveit (2001) noticed that, an increase in pH during respiration was attributed to acceleration of acids metabolism, resulting in increased pH. The above is supported by Sanudo-

Baraja *et al*. (2008), who obtained a 5.3 pH in green 'Maradol' papaya, which shows that pH tends to change, depending on the variety and the degree of ripeness of the fruit. However, low pH is preferred in fresh-cut fruits since it gives a better eating quality as well as against microbial growth.

5.3.5 Total Titratable Acidity (TTA)

The average TTA values recorded for by fresh-cut sunrise-reddish papaya fruits in Clam shell, Polyethylene film and Zip lock were 0.78, 0.73 and 0.91 respectively (Table 4.36). Therefore the low pH could be attributed to the different polymer characteristics of the packaging material that lead to slowly breathing and less oxygen content in it. This finding is in line with Perez-Gago *et al*. (2006) who reported that there is increase respiration intensity by fresh-cut fruits after peeling and slicing. Significant average high and low acidity was recorded by fresh-cuts papaya fruits under Shaded and Hawked methods of display between the hours (0-6) that fruits were collected (Table 4.36). The higher acidity could be attributed to the decreased hydrolysis of organic acids and subsequent accumulation of organic acid which were oxidized at slow rate because of decreased respiration. The results also recorded a higher significance of TTA for fresh-cut fruits that were displayed under hawked environment against a lower TTA by unshaded fruits. This might be due to temperature differential in which the different packaged fruits were exposed to.

5.3.6 Microbial Load

5.3.6.1 *Staphylococcus*

Fresh-cut sunrise-reddish papaya fruits in the three different packaging materials recorded the presence of Staphylococcus (Table 4.37). This could be attributed to poor postharvest handling practices by both wholesalers and retailers alike. According to Harris *et al*. (2003) the presence of Staphylococcus in the freshly-cut papaya fruits stems from poor food handling practices and temperature abuse rather than production or processing issue. Thus, the present study recorded significant difference for Staphylococcus counts in fresh-cut papaya fruits in Clam shell under hawked method of display compared to Zip lock that recorded a lower count.

5.3.6.2 *E. coli*

The study conducted recorded *E. coli* count in all the different packaging materials (Table 4.38). However, the treatments did not significantly influence the *E. coli* counts. The presence of *E. coli* recorded in the present study could be attributed to the open environment under which fresh-cut papaya were sold by the retailers. This give credence to Adams and Moss (1996) who reported, *E. coli* in fresh- cut fruits is used as a sanitation index. Research available demonstrates that the presence of E. coli in food has been linked up with the exposure of food to the environment that might have introduced this microorganism into them (Adams and Moss, 1996).

5.4 DISCUSSION OF RESULTS FROM EXPERIMENT II

5.4.1 Firmness of freshly-cut papaya fruits

Tissue softening is a critical factor with freshly-cut products and can limit shelf life. Freshly-cut fruit firmness is an important quality attribute that can be affected by cell softening enzymes present in the fruit tissue (Varoquaux *et al.,* 1990).

The research conducted revealed that, there was a firmness loss in fresh-cut sunrisereddish papaya fruits when the treatments were applied (Figure 4.6). The firmness loss decreased with increasing days in storage. Fruit firmness is linked with an increase of pectin solubility and depolymerisation of matrix polysaccharides which is believed to be an important factor in reduced rigidity of cell walls that lead to fruit softening (Brummell, 2006). Average firmness loss was higher in fresh-cut fruits in Zip lock and lower in Polyethylene film. This could be attributed to the different polymer characteristics of the different packaging materials that might have affected the metabolic activities in each of them. This is buttressed by Schlime and Rooney (1994) who reported that Zip lock and Polyethylene film are described as low density polyethylene film and moderate density polyethylene film and thus exhibit different transmission rate with respect to oxygen carbon dioxide and water vapour. The present study is therefore in line with Salveit (2001) who stated that bruised tissue during fruit peeling and cutting might have led to this condition. The same author further reported that tissue damage may have raised ethylene production that elevated the activities of the leached texture-related enzymes in cell walls of fruit tissue. Similar trend of decrease in firmness of orange with storage periods was reported by Tabatabaekoloor (2012). Siddiqui and Bangerth (1996), studying the structural changes in cell walls of apple during storage, suggested that storage at low temperatures can lead to a loss of rigidity of the fruit because of dissolution of the middle lamella and subsequent cell separation. Hence, this can explain the decline in firmness loss of the three treatments with storage days.

5.4.2 Moisture content of freshly-cut papaya fruits

Result of the keeping quality of the fresh-cut sunrise -reddish papaya fruits stored at 5 °C showed that, there was a general increase in the moisture content of the three different packaging materials. The moisture content of fresh-cut papaya fruits ranged from (86.81 - 89.17 %) after day 9 (Figure 4.7). These moisture values are therefore in agreement with Ahuja *et al*. (2008) statement that the moisture content in papaya fruits ranges from 85 – 92 %. The increase in moisture content might be attributed to the low temperature storage coupled with the different packaging materials that permitted a differential exchange of gases between the Modified Atmosphere Packaging and their surrounding environment. In a study conducted by Nwofia *et al*. (2012), similar reports were made of high moisture content in the pulp of papaya.

5.4.3 Total soluble solids of freshly-cut papaya fruits

All the treatments demonstrated a decrease in total soluble solids during the storage days (Figure 4.8). Thus, the decrease in total soluble solids might be attributed to the packaging materials and storage temperature that retarded the ripening and senescence process and simultaneously reduced the conversion of starch to sugar.

The present study conforms to findings of Rivera-Lopez *et al.* (2005), where TSS in ¾ ripe papaya cubes and slices decreased after 18-d of storage at 5 °C, 10 °C and 20 °C. They explained this finding on the assumption that sugars are the first substrate used during respiration. According to Rathore *et al. (*2007), an increase in total soluble solids is as a result of the gradual conversion of starch to simple sugars as fruits ripen. They further explained this to be due to the changes in the cell wall structure and breakdown of complex carbohydrates into simple sugars during storage. The present study is also in line with their findings and points out to the fact that the packaging materials and storage temperature affected the total soluble solids of the freshly-cut papaya fruits.

5.4.4 pH of Freshly-cut Papaya Fruits

Increase in pH value for all fresh-cut papaya fruits were observed after day 9 of storage at 5 °C (Figure 4.9). Since organic acids (citric and malic acids) are the substrates of enzymatic reaction during respiration, an increase in pH was expected during storage (Yaman and Bayoindirli, 2002).

Fresh-cut sunrise-reddish papaya fruits in Polyethylene film presented the lowest pH among all packages on day 1, but subsequent storage equalised it with that to Zip lock and Clam shell on days 5 and 7 respectively (Figure 4.9). The approximate pH of papaya has been reported as 5.2-6.0 (FDACFSAN, 2007).The initial pH in the present study was 5.46. However, studies performed by Sanudo Baraja *et al*. (2008) obtained a 5.3 pH in green "Maradol" papaya, which shows that pH tends to change, depending on the variety and the degree of ripeness of the fruit. The increasing trend in the current study is buttressed by John (2000) who indicated that the pH values of fruit flesh increases with the onset of maturation till ripening.

5.4.5 Total Titratable Acidity (TTA)

Decreases in the total titratable acidity of fresh-cut papaya fruits in all the treatments was observed during the 9-d of storage at 5 °C (Figure 4.10). However, higher TTA values are preferred during storage because they correlate with low pH values, thereby preventing the early growth of micro-organisms in freshly-cut fruits.

In consonance with the pH results (Figure 4.11), it was observed that TTA of freshcut papaya fruits in Zip lock decreased by 49.3 % after 9 days of storage (Figure 4.10). Clam shell showed the lowest in TTA (43.4 %), the same time, followed by Polyethylene film (48.3 %).

The decrease in TTA observed was in agreement with the results of Texeira *et al.* (2001), who reported that 'Formosa papaya chunks (2.5 cm x 5.0 cm) showed higher TTA reduction at 6 °C and 9 °C than 3 °C. The acid content of papaya is very low and comes from almost equal amount of citric and malic acids (Lancashire, 2007). Moreover, the author expounded that, the concentration of these acids normally decrease during ripening. **5.4.6 Shelf-life**

5.4.6.1 Colour Score

Colour is an important factor that contributes to consumer assessment of fresh-cut papaya quality. Therefore, the colour of fruits could denote the level of spoilage, contamination as well as disease infection. Generally, there was a decrease in the colour score of fresh-cut papaya fruits as they days advanced irrespective of the treatments (Figure 4.11). This could be attributed to the minimal processing, packaging material, oxygen availability and storage temperature that the papaya fruits were subjected to. Kader (2002) reported that, the level of browning in freshfruits is as a result of active PPO and phenolic compounds in the fruits. The present study revealed that Zip lock fruits were scored higher in colour than Clam shell and Zip lock. This implies that there were less concentration of PPO and phenolic compounds in Zip lock than the rest of the packaging materials. Quality loss in freshcut papaya has been attributed to surface browning. This give credence to McEvily *et al*. (1992), who reported that surface browning occurs as a result of oxidation in the fruit.

5.4.6.2 Aroma Score

Consumer decision to purchase fresh-cut fruits is invariably based on the appearance and textural quality. However, consumer repeat purchase depends significantly upon their satisfaction with flavour. The aroma score that was recorded for fresh-cut papaya fruits in the study was not significant (Figure 4.12). This could be partly due to less enzymatic reaction caused by cutting, respiration rate as well as minimal microbial activity. However, fresh-cut papaya fruits in Zip lock recorded a better aroma score than Clam shell and Polyethylene film. The results in the present research is in line with Kader (2002), who reported minimum soluble solids content and maximum titratable acidity to be acceptable flavour quality papaya (Kader, 2002).

5.4.6.3 Texture Score

The texture of fresh-cut sunrise-reddish papaya fruits recorded a decreased after day one. The decreased in texture was 5. 6% after day 9 (Table 4.41). This trend could be partly due to the ripening stage, fresh-cut processing of the fruits, different packaging materials coupled with microbial activity during the period of holding at 5°C. Research available indicates that Pectolitic enzymes have been identified or known to cause cell wall modification and degradation. This give credence to Mondal *et al*. (2008), who revealed that in different ripening stage in guava, ethylene increased with a subsequent decrease, causing a loss in firmness due to PG and PME activation. Paull *et al*. (1999) also noticed that, pectin and hemicelluloses increased with firmness loss which was facilitated by time and temperature. Moreover, Nunes *et al.* (2006) observed a similar trend in firmness loss when they conducted a study on papaya cultivars.

5.4.7 Microbial Load on Freshly-cut Papaya Fruits

5.4.7.1: *Escherichia Coli* (E. coli)

The laboratory analysis indicated that, all the freshly-cut papaya fruit samples had the presence of *E. coli.* The range obtained (Figure 4.13) was within the acceptable range for human consumption. Thus the presence of *E. coli* in all the freshly-cut papaya fruits in the respective packaging materials is in agreement with Barth *et al*. (2010), who stated that fruits and vegetables handled in the natural cannot be entirely free from microbes, pertaining to the fact that the retailers most often process the fruits in the open which exposes the fruits to microorganisms, hence contamination of the fruits. Retailers bought the papaya fruits from the wholesalers from the market and probably not handled, processed and packaged them well thereby getting them exposed to microbial contamination. Findings by Mukherjee *et al.* (2006) revealed that contaminated fruits and vegetables can be a means for the transmission of bacterial and other pathogens capable of causing human illness and in many cases, food borne pathogens have been isolated from fruits and vegetables, which might have been contaminated during harvesting, postharvest handling and distribution.

Olsen *et al*. (2000) attest to the fact that Salmonella, *E. coli*, Norwalk-like, hepatitis A, and parasitic pathogens are the microbes that are invariably associated with fresh produce related outbreaks. Even though the handling practices by the retailers were the same, the initial contamination during harvesting, postharvest handling and transportation might have led to the occurrence of *E. coli* in all the fresh-cut papaya samples. Therefore infection might have occurred at a number of points during production, harvest, processing, distribution and sale. Harris *et al*. (2003) explained that, cross contamination of food items may also lead to the occurrence of *E. coli*.

Fresh fruits and vegetables can pose a serious food safety risk since they are consumed raw and are also susceptible to be contaminated by faecal material in the soil (Mukherjee *et al.,* 2004). It can be inferred from the results of the current study that the consumption of these contaminated fresh-cut papaya fruits by consumers may not result in serious disease outbreak as the values obtained were within the acceptable range.

5.4.7.2: *Staphylococcus*

According to Harris *et al*. (2003) the presence of *Staphylococcus* in the freshly-cut papaya fruits stems from poor food handling practices and temperature abuse rather than production or processing issue. The presence of *Staphylococcus* in the product is not surprising considering that papayas are hand peeled and the microorganism is often associated with handling by humans.

Generally, the poor handling practices by both wholesalers and retailers might have contributed to the occurrence of *Staphylococcus* in all the packaged fresh-cut papaya fruit samples (Figure 4.14).

5.4.7.3 *Salmonella*

The occurrence of *Salmonella* in the freshly-cut papaya was not observed in all the samples (Table 4.45). *Salmonella* species are common in a wide variety of produce items and have caused a significant number of outbreaks associated with seeded sprouts, tomatoes, melons and fruit juices (Harris *et al.,* 2003). The absence of *Salmonella in* all the packaged freshly-cut papaya fruits suggested that they did not contain faecal matter and thus the occurrence of E. coli and *Staphylococcus* might have been from the handling practices and the storage conditions.

6.0 CONCLUSION AND RECOMMENDATIONS

The research was aimed at determining the effect of retail packaging material and storage temperature on the keeping quality of fresh-cut sunrise-reddish papaya fruits sold in the Kumasi Metropolis. A preliminary field survey was conducted in the Kumasi Metropolis of the Ashanti region of Ghana, to select markets, identify the types of retail packaging materials as well as select respondents randomly for the study. Further on, fresh-cut papaya fruits in three different packaging materials under three methods of display were collected randomly at two different times and studied for their firmness, moisture content, pH, total soluble solids, total titratable acidity and microbial load. Moreover, sunrise-reddish papaya fruits at the breaker stage which were harvested at Nobewam in the Ashanti region of Ghana were processed and packaged in three different packaging materials and stored at 5 °C for 9 days for the determination of their physico-chemical ,microbial as well as shelf-life properties every two days.

- The field survey revealed that, majority (84 %) of the retailers used Polyethylene films while a few (16 %) used the Clam shell packaging. The higher percent which was recorded by Polyethylene was attributed to their availability, cost effective and ease of usage.

- Sunrise-Reddish papaya fruits (55 %), were widely traded than the Kapohoyellowish (45 %) by retailers which were supplied by the wholesalers. This was partly due to the sweet taste, nice smell and the crispy texture or nature of the sunrise-reddish variety that was highly patronized by consumers.

- The survey also revealed that, Consumers bought their fresh-cut papaya fruits from any of the methods of display with particular reference to availability, nearness as well as the cleanliness of the retailer.

- Laboratory results revealed that, fruits in Clam shell retained their firmness better than those in Polyethylene films, which were also better than those in Zip locks irrespective of the time the fruits were collected. This may be partly due to Clam shell being a high density polyethylene film. Even though a high moisture content was recorded by the three different packaging materials, the treatments did not significantly influence the moisture content. The interaction between packaging materials and method of display showed that Hawked fruits were significantly ($p<0.01$) higher in pH and total titratable acidity than shaded and unshaded fruits. Staphylococcus counts in Zip lock under Shade condition recorded the lowest count irrespective of the time the fruits were collected. Fresh-cut Sunrise-Reddish papaya fruits in Zip lock recorded the lowest pH and Staphylococcus counts which gives the fruit a good eating quality.

- Laboratory experiment also revealed that, the three different packaging materials did not affect the firmness, moisture content, total soluble solids and pH of freshly-cut papaya stored at 5°C. However, fresh-cut papaya fruits in Zip lock significantly ($P<0.01$) influenced the TTA. The study also showed that, moisture content and pH of fresh-cut sunrise-reddish papaya fruits increased significantly ($p<0.01$) on day 9 than the rest of the days. In terms of shelf-life, Zip lock recorded a higher significant ($p<0.01$) colour and aroma score than the rest of the packaging materials. This might be due to the micro- climate that was created by Zip lock.

- From the results, it can be concluded that, Zip lock as a retail packaging material under the three methods of display or storage environment should be used since it gave a better keeping quality of moisture content, total soluble solids, total titratable acidity, shelf-life and lower microbial load than polyethylene films and clam shells.

6.1 Recommendations

Based on the research findings the following recommendations were made:

1. Results of the survey revealed that other papaya fruit varieties were retailed by the retailers. To this end, it is recommended that similar research work is carried on them.
2. The results also brought to light different ripening stage of papaya fruits as was observed during the survey. It is recommended that these other varieties are given attention in future research.

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APPENDICES

APPENDIX I

Table 4.9: Variety of Papaya Patronized by Consumer

Variety	Frequency	Percentage
Kapoho: yellow-orange	39	39.0
Sunrise: reddish-orange	55	55.0
Both	6	6.0
Total	100	100.0

Source: Field Survey, October 2014

Table 4.18: Ripening Stage of Papaya Acquired for Sale

Stage	Frequency	Percentage
Breaker	7	14.0
Half ripe	6	12.0
Both	37	74.0
Total	50	100.0

Source: Field Survey, October 2014

Table 4.25: Consumers' Preferred Choice of Packaging Material

Material	Frequency	Percentage
Clear polyethylene film	69	69.0
Clam shell plastic	11	11.0
Both	20	20.0
Total	100	100.0

Source: Field Survey, October 2014 Table
4.27: Location of Sale Point

Location	Frequency	Percentage
Under shade	9	18.0
Hark in the sun	10	20.0
Unshaded	31	62.0
Total	**50**	**100.0**

Source: Field Survey, October 2014

Table 4.28: Consumer perception of freshly-cut papaya as affected by Packaging material

Aspect Affected	Frequency	Percent
Texture	37	37.0
Taste	22	22.0
Nutritional quality	24	24.0
Other effects	8	8.0
No effect	9	9.0
Total	100	100.0

Source: Field Survey, October 2014

APPENDIX II

Plate 1: Sorting of papaya fruits

Plate 2: Shaded method of display

Plate 3: Hawked method of display

Plate 4: Unshaded method of display

APPENDIX III

SURVEY QUESTIONNAIRE KWAME NKRUMAH UNIVERSITY OF SCIENCE AND TECHNOLOGY, KUMASI FACULTY OF AGRICULTURE DEPARTMENT OF HORTICULTURE

QUESTIONNAIRE TO WHOLESALERS ON EFFECT OF RETAIL PACKAGING MATERIAL AND STORAGE TEMPERATURE ON THE NUTRITIONAL QUALITY AND SHELF LIFE OF FRESH-CUT PAPAYA IN ASHANTI REGION

I am a student of the above mentioned university pursuing Mphil Postharvest Physiology. The information that will be obtained will be used for academic purposes and will be treated as confidential.
Please be frank with your responses and tick ( ) where necessary.

BIODATA AND BACKGROUND

1. Gender: ( ) M ( ) F
2. Age: ( ) 15 – 20 ( ) 21 – 26 ( ) 27 – 32 ( ) 33 – 38 ( ) 39 – 44 ( ) 45 and above
3. Marital status: ( ) Single ( ) Married ( ) Divorced ( ) other, please specify …......
4. Religious denomination: ( ) Christianity ( ) Islamic ( ) Traditionalist ( ) Other, specify …
5. Nationality: ( ) Ghanaian ( ) Non Ghanaian

EDUCATIONAL BACKGROUND

6. Educational level: ( ) Basic ( ) Senior High ( ) Tertiary ( ) Other, please specify …......

SOCIO-ECONOMIC STATUS

7. How many years have you been trading in papaya fruits? ( ) 1 yr. ( ) 2 yrs. ( ) 5 yrs. ( ) 7yrsif other, specify ….................................. yrs.
8. Why did you go into papaya trading? () desire to get money ( ) family business ( ) unemployment ( ) other. If other, specify …...............................

SOURCE OF PAPAYA FRUITS

9. Which of the following source (s) do you obtain papaya fruits? ( ) Farmers ( ) other wholesalers ( ) If other, specify …..........................
10. Which of the following solo papaya do you buy from your source? ( ) kapoho: yellow orange flesh ( ) sunrise: Red Orange flesh ( ) both 11. Why do you obtain your papaya fruits from this source?
12. How often do you obtain your papaya fruits from the source? ( ) Daily ( ) weekly ( ) Monthly ( ) occasionally
13. Which of the following materials do you buy your papaya fruits in? ( ) sack ( ) crate ( ) basket
14. What is the price per the material in which you buy your papaya fruits from your source? ( ) 10.00 ( ) 15.00 ( ) 20.00 ( ) 30.00 ( ) other, please specify ….........
15. What quantity do you buy from your source? ( ) 10 – 20 ( ) 21 – 30 ( ) 31 - 40 ( ) If other, specify ….........

SORTING

16. Do you sort your fruits before bagging? ( ) Yes ( ) No

If you yes, answer 17.If no, move to 18

17. Which of the following forms do you sort the fruits into? ( ) Ripped fruits ( ) Unripe fruits ( ) Damaged / Broken fruits

STORAGE

18. Do you store your papaya fruits before transportation? ( ) Yes ( ) No

If yes, answer 19.If you no, move to 20

19. How many days do you store your papaya fruits? …......................

TRANSPORTATION

20. With which of the following do you transport your papaya fruits to the market?

( ) Cargo truck ( ) trotro ( ) Taxi If other, specify ….......................................

21. Which time of the day do you transport your papaya fruits to the market?

( ) morning ( ) afternoon ( ) evening

22. How long does it take you to transport your papaya fruits to the market?

23. Which bagging material or container do you put your fruit in during transportation?

( ) sack ( ) plastic container ( ) woven basket ( ) If other, specify.............

24. Which of the following losses do you incur after arriving at your destination (market)?

Give your answer in terms of number (

) Damaged / Bruised ….................

( ) Broken …............................

THAK YOU

SECTION B: SAMPLE QUESTIONNAIRE TO RETAILERS

Please be frank with your responses and tick (✓) where necessary.

BIODATA AND BACKGROUND

1. Gender: ( ) M ( ) F

2. Age: ( ) 15-20 ( ) 21-26( ) 27-32 ( ) 33-38 ( ) 39 and above

3. Marital status: ( ) Single ( ) Married ( ) Divorced ( ) If others, specify

4. Religious denomination: ( ) Christianity ( ) Islamic ( ) Traditionalist

( ) if others specify...........................

5. Nationality: ( ) Ghanaian ( ) Non Ghanaian

EDUCATIONAL BACKGROUND

6. Educational level: (.) Basic (.) Senior High (.) Tertiary

SOCIO –ECONOMIC STATUS

7. How many years have you been trading in papaya? ( ) 1 yr. ( ) 2 yrs. ( ) 5 yrs. ( ) 7 yrs. ( ) If less or more, specify..........................yrs.

8. Why did you go into papaya trading? ( ) unemployment. ( ) Desire to get money ( ) Family business. ( ) If other(s), specify..

9. How would you rate your profit margin over the years? ( ) Stagnant. ( ) Increasing ( ) Decreasing ( ) fluctuating

10. What has contributed to the answer you choice in question (9) above? ....

SOURCE OF PAPAYA

11. Which of the following source (s) do you obtain your papaya fruits? ( ) Farmers only ( ) Wholesalers only ( ) Farmers and Wholesalers

12. Which of the following Solo variety (ies) of papaya do you obtain from your source(s)? ( ) Kapoho: Yellow -Orange flesh. ( ) Sunrise: Reddish Orange 13. At what ripening stage(s) do you obtain your fruits from the source? ( ) Breaker. ( ) 1/2 ripe. ( ) Fully ripe. ( ) Over ripe

14. Which of the following range or count of papaya do you purchase /buy from your Source? Less than 50 ( ) 50-100 ( ) 101-150 ( ) 151- 200 (.) 200 and above

15. What is the cost range of your papaya purchased in (question 14 above)? ( ) Gh 20-50 ( ) Gh 51-81(.) Gh 82 and above

16. How often do you get papaya from your source? ( ) Daily (.) Weekly (.) Monthly ( ). Occasionally (.) If other(s), specify..................................

17. Do you often get enough papaya from your source? (.) Yes. (.) No
If no, move to 18, if yes answer question 19

18. Why do you not get enough papaya? ....

19. Why do you obtain your papaya fruits from that source? (.) Price is moderate (.) Fruits are available all the time (.) Distance is not far
(.) If other(s), specify...

TRANSPORTATION OF PAPAYA

20. What type of transport do you use to carry your papaya from the source(s) to the point of sales? (.) Cargo truck. (.) Open truck. ( ) Taxi ( ) Boot of vehicles. If other(s), specify...

21. What type of bagging material do you put your papaya fruits in before transportation? Cocoa Sack. ( ) Woven basket ( ) Plastic container
( ) If others, specify...

22. Which time of the day do you normally transport your fruits from the source to your destination? ( ) Morning ( ) Afternoon ( ) Evening

23. What is the distance between your point of source and sales? ( ) 1-5 miles (.) 6-10 miles ( ) 11-15 miles ( ) 16 miles and above

24. How long does it take you to transport your fruits from the source to the point of sales? ( ) 30 minutes ( ) 1 hour ( ) 1 1/2 hours ( ) 2 hours ( ) If less or more, specify..

25. Which of the following roads do you transport your fruits from the source to your point of sale? ( ) Tarred /Asphalt (.) Untarred

SORTING OF FRUITS

26. Do you store your papaya fruits immediately after transportation ( ) Yes. (.) No if no, move to question 27, if yes answer question 28

27. Why...

28. How many days do you store your papaya fruits after transportation before sorting? ( ) A day ( ) Two days ( ) Three days ( ) Four days and above

28. After transportation, which of the following forms of losses do you incurduring sorting (give answer in terms of number?)
( ) Damaged/Bruised fruits....................... (.) Discarded/rotten fruits....

PREPARATION OF FRUITS

29. Do you clean your fruits? ( ) Yes () No

If no, move to question 30, if yes answer question 31

30. Why? ....
31. How do you clean your fruits? ( ) Wash with water only ( ) Wash with Water and sponge ( ) Wash with water and brush ( ) If other(s), specify........
32. What is the source(s) of water for cleaning the papaya fruits? ( ) well ( ) pipe

( ) River. ( ) Stream ( ) If other, specify……………………

33. Which of the following cutting tools/equipment do you use for peeling the fruits?

(.) Sharp stainless-steel knife ( ) Blunt stainless-steel knife

34. Do you sterilize your cutting tools/equipment before peeling your fruits? ( ) Yes. ( ) If no, move to question 35, if yes answer 36
35. Why are your cutting tools/equipment not sterilize? ( ) Do not have a

sterilizer ( ) Do not know how to sterilize

36. Which of the following ways do you sterilize them? ( ) Wash with hot water ( ) Wash with only cold water ( ) Wash with water and antiseptic ( ) If other (s), specify...
37. How many fruits do you prepare at a time for sale? ( ) 3 ( ) 5 ( ) 6 ( ) If less or more, specify.................................
38. How many minutes does it take you to sell your processed and packaged

papaya fruits? ( ) 5 minutes ( ) 15 minutes ( ) 30 minutes ( ) 1 hour

( ) If less or more, specify..

PACKAGING OF FRUITS

39. What type of packaging material (s) do you use? ( ) Clear Polyethylene film

( ) Clamp Shell Plastic ( ) If other(s), specify..

40. Why do you use this type of packaging material (s)? (.) It is cheap ( ) It is attractive () It is liked by consumers ( ) If other(s), specify..........................
41. Do you package your sliced papaya immediately after preparation? ( ) Yes ( )

No

If no move to question 42, if yes answer question 43

42. How many minutes does it take you to package your fruits after preparation? ( ) 2 minutes. ( ) 5 minutes ( ) 3 minutes ( ) If less or more, specify...................

43. Would you change your packaging material if another one is proven to be

effective than what you are using? ( ) Yes (.) No If

no move 44, if yes answer question 45

44. Why...

HANDLING OF PACKAGED FRUITS

45. Where do you sell your processed and packaged fruits? (.) Under shade ( )

Hark in the sun ( ) Open air. ( ) If other(s), specify..................................

46. Do people complain after buying your processed and packaged papaya? ( ) Yes ( ) No

If no move to question 47, if yes answer question 48

47. What do they complain about? ....
48. How much profit do you make daily from your sales (processed and packaged papaya)? ( ) Gh7 ( ) Gh 10 ( ) Gh15 ( ) If less or more, specify

Gh..............

49. How much is lost daily from what you produce to sell (processed and packaged)? ( ) Gh 10 ( ) Gh 15 ( ) Gh 20 ( ) If less or more, specify Gh...........
50. What do you do to the packaged fruits if all are not sold out? ( ) Give to friends (.) Give to relatives ( ) Give to animals ( ) Throw away ( ) If other(s), specify............................
51. How do you extend the shelf life of your processed and package papaya fruits

( ) Refrigerate ( ) form into papaya juice and store ( ) Store in the room

( ) None of the above

52. Which of the following challenges do retailers face in the processing and packaging of fresh cut papaya? ( ) Lack of storage facilities. ( ) lack of ready markets. ( ) If other(s) specify................

THANK YOU.

SECTION C: SAMPLE QUESTIONNEIRE TO CONSUMERS

Please be frank with your responses and tick (✓) where necessary.

BIODATA AND BACKGROUND

1. Gender: ( ) M ( ) F
2. Age: ( ) 15-20 ( ) 21-26 ( ) 27-33 ( ) 34-39 ( ) 39 and above
3. Marital status: ( ) single ( ) married ( ) divorced
4. Religious denomination: ( ) Christianity ( ) Islamic ( ) Traditionalist ( ) If other(s), specify...................................
5. Nationality: ( ) Ghanaian ( ) Non Ghanaian

EDUCATIONAL BACKGROUD

6. Educational level: ( ) Basic ( ) Senior High ( ) Tertiary ( ) if other (s), specify....

SOCIO –ECONOMIC STATUS

7. Occupation..
8. How often do you buy processed and packaged papaya? ( ) Daily ( ) Weekly ( ) Monthly ( ) Occasionally

SOURCE OF FRESHS-CUT PAPAYA

9. Where do you buy your processed and packaged papaya fruits? ( ) Retailers under shades ( ) Papaya hawkers ( ) both
10. Why do you buy from the above (9) source(s)? ( ) Papaya are cheap (.) Papaya are nicely processed and packaged ( ) If other specify..........................
11. How often do you buy processed and packaged papaya from the above (11) source(s)? ( ) Daily ( ) Weekly. ( ) Monthly ( ) Occasionally
12. What major reason makes you go for processed and package papaya? ( ) Time saving ( ) Convenience ( ) Look attractive
13. Which of the following Solo variety of processed and packaged papaya do you buy from your source (s)? ( ) Kapoho: Yellow- Orange flesh. ( ) Sunrise: Reddish Orange
14. Why do you buy this variety? ( ) It is sweet ( ) It taste better ( ) It has a nice smell ( ) If other(s), specify....................................

PREPARATION OF FRUITS

15. Are you aware of how processors clean their papaya before processing and packaging? ( ) Yes ( ) No If no move to 16, if yes answer question 17
16. Which of the following do they use in cleaning the papaya fruits? ( ) Cold water ( ) warm water ( ) Do not know
17. Do they clean their cutting tools/equipment? ( ) Yes ( ) No If no move to 18, if yes answer question 19
18. What do they use in sterilizing them? ( ) Wash with hot water ( ) Wash with only cold water. ( ) Wash with water and antiseptic ( ) Do not know

PACKAGING OF FRUITS

19. Which type of packaging material is used to package the processed papaya fruits? ( ) Clear Polyethylene film ( ) Clamp Shell plastic ( ) both

20. Why do you buy in this type of packing material? (.) It is attractive ( ) It is cheap ( ) Easy to handle ( ) If other(s), specify......................
21. Which shape (s) do you buy your processed and packaged papaya? ( ) cubes
( ) rectangular slice ( ) both
22. How much do you buy sliced packaged papaya fruit? ( ) Gh 1 ( ) Gh1.5 (.) Gh 2
23. In your opinion, which aspect of the sliced fruit does the package affect? (.) Texture (.) Taste (.) Nutritional quality ( ) If other (s), specify...........

HANDLING OF PACKAGED FRUITS

24. After processing and packaging of the papaya fruits where do they display them for sales? ( ) directly on tables ( ) Open trays on tables
() If other(s), specify..
25. Have you ever complained after consuming processed and packaged papaya fruits? ( ) Yes. ( ) No

If no move to 29, if yes answer question 30

26. What did you complain about? ....
27. Consumers perception about retail packaging and processing of papaya

………………………………………………

THANK YOU

APPENDIX IV

ANALYSIS OF VARIANCE (ANOVA)

ANOVA for firmness of fresh-cut papaya fruits

Source	DF	SS	MS	F	P
Rep	2	2.5317	1.26583		
MD	2	16.0550	8.02750	34.82	0.0000
PM	2	0.5717	0.28583	1.24	0.3158
MD*PM	4	0.6183	0.15458	0.67	0.6218
Error	16	3.6883	0.23052		
Total	26	23.4650			

Grand Mean 3.9000
CV 12.31

ANOVA for moisture content of fresh-cut papaya fruits

Source	DF	SS	MS	F	P
Rep	2	14.702	7.3512		
MD	2	94.109	47.0543	3.02	0.0770
PM	2	17.519	8.7594	0.56	0.5805
MD*PM	4	19.797	4.9491	0.32	0.8618
Error	16	249.071	15.5669		
Total	26	395.197			

Grand Mean 85.147
CV 4.63

ANOVA for total soluble solids of fresh-cut papaya fruits

Source	DF	SS	MS	F	P
Rep	2	5.3246	2.66231		
MD	2	6.3163	3.15815	80.80	0.0000
PM	2	0.2341	0.11704	2.99	0.0786
MD*PM	4	0.2093	0.05231	1.34	0.2986
Error	16	0.6254	0.03909		
Total	26	12.7096			

Grand Mean 4.6963
CV 4.21

ANOVA for pH of fresh-cut papaya fruits

Source	DF	SS	MS	F	P
Rep	2	0.68389	0.34194		
MD	2	0.53556	0.26778	19.23	0.0001

PM	2	0.01722	0.00861	0.62	0.5512
MD*PM	4	0.01556	0.00389	0.28	0.8871
Error	16	0.22278	0.01392		
Total	26	1.47500			

Grand Mean 4.2667
CV 2.77

ANOVA for total titratable acidity of fresh-cut papaya fruits

Source	DF	SS	MS	F	P
Rep	2	0.01202	0.00601		
MD	2	0.41129	0.20564	30.76	0.0000
PM	2	0.14229	0.07114	10.64	0.0012
MD*PM	4	0.04509	0.01127	1.69	0.2023
Error	16	0.10698	0.00669		
Total	26	0.71767			

Grand Mean 0.8078
CV 10.12

ANOVA for Staphylococcus counts on fresh-cut papaya fruits

Source	DF	SS	MS	F	P
REP	2	3789091	1894545		
PM	2	7525015	3762507	5.28	0.0173
MOD	2	1638449	819225	1.15	0.3413
PM*MOD	4	5720664	1430166	2.01	0.1418
Error	16	1.139E+07	712095		
Total	26	3.007E+07			

Grand Mean 1246.4
CV 67.71

ANOVA for Escherichia coli count on fresh-cut papaya fruits

Source	DF	SS	MS	F	P
REP	2	1.364E+07	6819480		
PM	2	8619706	4309853	3.92	0.0411
MOD	2	677646	338823	0.31	0.7389
PM*MOD	4	4722407	1180602	1.07	0.4015
Error	16	1.758E+07	1098621		

Total	26	4.524E+07

Grand Mean 2263.8
CV 46.30

ANOVA for firmness of fresh-cut papaya at 5ºC

Source	DF	SS	MS	F	P
REP	2	0.02711	0.01356		
PM	2	0.21378	0.10689	2.09	0.1427
DOS	4	7.08578	1.77144	34.62	0.0000
PM*DOS	8	0.56622	0.07078	1.38	0.2467
Error	28	1.43289	0.05117		
Total	44	9.32578			

Grand Mean 4.2622
CV 5.31

ANOVA for moisture content of fresh-cut papaya at 5ºC

Source	DF	SS	MS	F	P
REP	2	6.762	3.3811		
PM	2	1.639	0.8196	0.55	0.5842
DOS	4	105.361	26.3404	17.61	0.0000
PM*DOS	8	12.443	1.5554	1.04	0.4309
Error	28	41.882	1.4958		
Total	44	168.088			

Grand Mean 85.492
CV 1.43

ANOVA for total soluble solids of fresh-cut papaya at 5ºC

Source	DF	SS	MS	F	P
REP	2	0.4813	0.24067		
PM	2	2.5013	1.25067 p	6.92	0.0036
DOS	4	26.2658	6.56644	36.35	0.0000
PM*DOS	8	1.2409	0.15511	0.86	0.5615
Error	28	5.0587	0.18067		
Total	44	35.5480			

Grand Mean 4.1400
CV 10.27

ANOVA for pH of fresh-cut papaya at 5ºC

Source	DF	SS	MS	F	P
REP	2	0.0084	0.00422		
PM	2	0.1351	0.06756	2.33	0.1158
DOS	4	8.3547	2.08867	72.06	0.0000
PM*DOS	8	2.1560	0.26950	9.30	0.0000
Error	28	0.8116	0.02898		
Total	44	11.4658			

Grand Mean 5.8378
CV 2.92

ANOVA for Total Titratable Acidity of fresh-cut papaya at 5ºC

Source	DF	SS	MS	F	P
REP	2	0.00906	0.00453		
PM	2	0.06367	0.03184	9.02	0.0009
DOS	4	0.44273	0.11068	31.37	0.0000
PM*DOS	8	0.00892	0.00112	0.32	0.9533
Error	28	0.09880	0.00353		
Total	44	0.62318			

Grand Mean 0.4423
CV 13.43

ANOVA for colour of Fresh-cut papaya fruits

Source	DF	SS	MS	F	P
REP	2	0.3111	0.15556		
PM	2	11.5111	5.75556	28.33	0.0000
DOS	4	8.3111	2.07778	10.23	0.0000
PM*DOS	8	1.1556	0.14444	0.71	0.6798
Error	28	5.6889	0.20317		
Total	44	26.9778			

Grand Mean 1.9778
CV 22.79

ANOVA for texture of fresh-cut papaya fruits

Source	DF	SS	MS	F	P
REP	2	1.11111	0.55556		
PM	2	34.4444	17.2222	217.00	0.0000
DOS	4	1.474E-30	3.685E-31	0.00	1.0000
PM*DOS	8	1.284E-31	1.605E-32	0.00	1.0000
Error	28	2.22222	0.07937		
Total	44	37.7778			

Grand Mean 2.2222
CV 12.68

ANOVA for aroma of fresh-cut papaya fruits

Source	DF	SS	MS	F	P
REP	2	4.9333	2.46667		
PM	2	3.6000	1.80000	6.00	0.0068
DOS	4	0.0889	0.02222	0.07	0.9895
PM*DOS	8	0.1778	0.02222	0.07	0.9996
Error	28	8.4000	0.30000		
Total	44	17.2000			

Grand Mean 1.8000
CV 30.43

ANOVA for Escherichia coli on fresh-cut papaya fruits at 5°C

Source of variation	d.f	s.s	m.s	v.r	F pr.
Replication	2	32625	16312		
PM	2	222907	111453	25.23	0.0000
DOS	4	374290	93572	21.19	0.0000
PM*DOS	8	142968	17871	4.05	0.0027
Error	24	123668	4417		
Total	44	896458			

Grand Mean 143.22 CV
46.402

ANOVA for Staphylococcus on fresh-cut papaya fruits at 5°C

Sources	d.f	s.s	m.s	v.r	F pr.
Replication	2	7123.5	3561.76		
PM	2	7649.9	3824.96	5.93	0.0071
DOS	4	39565.0	9891.24	15.34	0.0000
PM*DOS	8	3319.4	414.93	0.64	0.7348

Error	28	18055.8	644.85
Total	44	7571.6	

Grand Mean 55.089
CV 46.10